

PH-3500

Profile Projector

User's Manual

Read this User's Manual thoroughly
before operating the instrument. After reading,
retain it close at hand for future reference.

Mitutoyo

CONVENTIONS USED IN USER'S MANUAL

Safety Precautions

To operate the instrument correctly and safely, Mitutoyo manuals use various safety signs (Signal Words and Safety Alert Symbols) to identify and warn against hazards and potential accidents.

The following signs indicate general warnings:



Indicates an imminently hazardous situation which, if not avoided, will result in serious injury or death.



Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury or property damage.

The following signs indicate specific warning or prohibited actions, or indicate a mandatory action.:



Alerts the user to a specific hazardous situation. The given example means "Caution, risk of electric shock".



Prohibits a specific action. The given example means "Do not disassemble".



Specifies a required action. The given example means "Ground".



WARNING



- Do not modify this instrument.
Risk of fire or electric shock.
- Do not bend, twist, pull, or modify the power cord.
Risk of fire or electric shock.
- Do not remove the front panel, rear panel, side panel or covers of this instrument.
Risk of electric shock.



- Only operate this instrument at the specified voltage.
Risk of fire or electric shock.



- Do not set up this instrument on an unstable bench.
The instrument may fall.
Risk of injury.



- Do not place a vessel containing liquid near the instrument.
Risk of fire or electric shock.
- Unplug the power cord and contact Mitutoyo if liquid has entered the instrument.
Risk of fire or electric shock.



- Unplug the power cord if replacing a fuse.
Risk of electric shock.



- The AC outlet incorporated with the instrument is only available for Mitutoyo accessories.
Do not plug in other equipment.
Risk of fire.



- Should this system be used under abnormal conditions such as heat radiation, smoking, and nasty smell generation, there is a risk of fire or electric shock. Immediately turn off the power switch, then unplug the power plug from the outlet.
Contact your dealer or the nearest Mitutoyo service network.



CAUTION



- Unplug the power cord if performing maintenance.



- Do not pull the cable to unplug the power cord.
Hold the plug and pull to prevent cord breakage.
Risk of fire or electric shock.



- Do not connect/disconnect or touch the plug with wet hands.
Risk of electric shock.



- Keep the power cord away from heaters.
Risk of fire or electric shock with melted cable insulation.



- Only use the specified fuse.
Risk of fire or electric shock.



- Do not block the ventilation outlets.
Risk of fire due to internal heat build up.



- Only use the specified batteries.
Risk of fire or injury with battery leakage or explosion.
- Insert the batteries properly as indicated on the instrument.
Risk of fire or injury with battery leakage or explosion.



- For quick power shutoff install this system at a site where the system power plug can be easily identified and quickly accessed to be unplugged.



CAUTION



- Do not apply excessive force to the instrument.
Risk of instrument failure, damage, or decreased accuracy.



- Only hold the specified parts of the instrument if transporting.
Risk of instrument failure, damage, or decreased accuracy.



- Exercise care so as not to pinch or hurt your fingers
if mounting/dismounting accessories.



- Only use the accessories specified in the User's Manual provided
with the instrument.
Risk of fire, electric shock, and instrument failure.



- Do not touch the lamp and surrounding region
while the lamp is lit or for a period of time after it has been turned off.
Risk of burn.

PRECAUTIONS

1. **Operation manual**
To obtain the best possible performance and long service life from your Mitutoyo Profile Projector PH—3500, please read this Operation Manual carefully prior to setup and operation.
2. **Handling**
Since the PH—3500 Profile Projectors incorporate high precision components of large weight, take special care so that no part of the projector is subjected to impact or excessive force when it is being installed, set up or operated.
Use the carrying handles on both sides of the projector to lift or carry the Profile Projector during unpacking and setting up. Never apply pressure to the control panel, microstage or other important parts.
3. **Installation site**
Select a location where the profile projector is not exposed to extreme temperatures, sudden temperature changes, high humidity, oil, direct sunlight, or vibration. In addition, the machine should be placed on a rigid stand. Although a dark setup location is not required, take care to shield the projection screen from direct light.
4. **Power source/grounding**
A single-phase power supply must be used with the profile projector. Confirm that the voltage selector on the power panel(right-hand side of the machine)is correctly set to the line voltage. Use the supplied power cord only. To ensure safety, ground the profile projector.
5. **Replacement parts**
Use only the specified fuse and lamp, and follow the procedures described in this manual.
Never attempt to remove the cover/panel or disassemble components except for those parts associated with consumable item replacement. This could cause machine failure or produce low-quality images.
6. **Dust and stain protection for the lens**
Never touch the lens, mirror, or bulb in order to avoid fingerprints, dust or oil. Ensure that these optical parts are always kept clean. Refer to 4.1 Maintenance of Optical Components for proper lens maintenance.
7. **Microstage**
Observe the following points when you operate the microstage. If you don't, the system may be damaged.
 - The maximum angle of the swivel is 10 degrees.
8. **Warranty**
In the event that the Mitutoyo PH—3500 should prove defective in workmanship or material, within one year from date of purchase for use, it will be repaired or replaced, at our option, free of charge upon its return to us prepaid.

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PH—3500

Profile Projector

1. OUTLINE

1.1

Outline

The Mitutoyo Profile Projector PH-3500 are advanced instruments to project a workpiece surface or contour on a screen for dimensional measurements and observation.

In addition to the ordinary measuring functions where the workpiece dimensions are measured by fitting a scale on the projection screen or are compared with a reference overlay chart to inspect the dimension or from deviation, this profile projector incorporates a digital-type angle counter that facilitates angle measurement conventionally thought difficult for standard profile projectors. Featuring also a standard microstage which incorporates X, Y-axis counters, this projector can be connected with various types of Mitutoyo counter units. These features allow a system to be configured to fully respond to customers' requirements.

In addition, this profile project can be connected with external data processors, such as the Mitutoyo MICROPAK-7 (Statistical Data Processing System), thus permitting a wide range of applications including statistical process control and quality control.

1.2

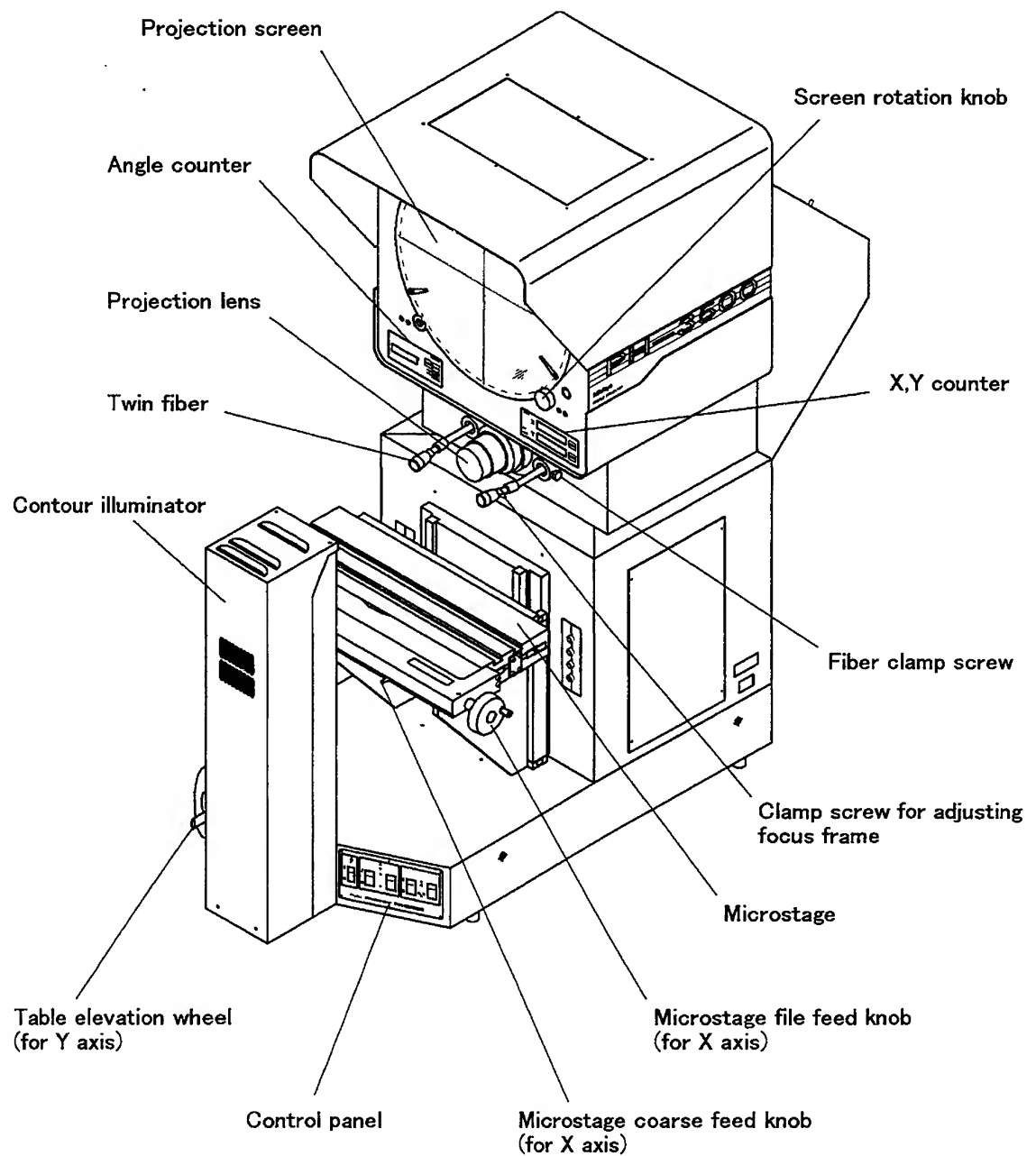
Features

- The PH-3500 are bench-type profile projectors which have a protractor screen with an effective diameter of 353mm and a horizontal light axis. Four types of high-performance projection lenses are available, 5X, 10X, 20X, and 50X magnifications.
- The microstage has a large loading capacity that enables a heavy workpiece, such as a formed cutter, hob-gear, large screw threads, and cutters, to be measured.
- A long list of accessories facilitates easy workpiece set-up and enhances measurement efficiency.
- Thanks to a built-in X, Y-axis counter and a built-in angle counter, quick measurement can be performed.
- The twin fiber illumination unit is provided as standard. It is suitable for spotlighting.

1. OUTLINE

1.3 Nomenclature

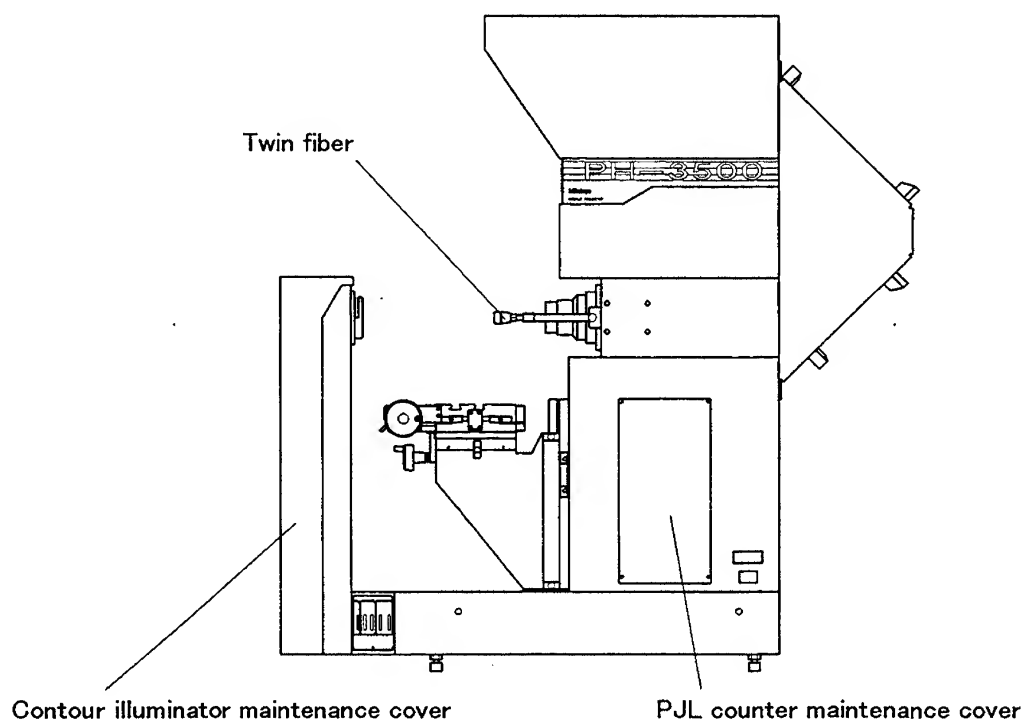
1.3.1 Front view



1. OUTLINE

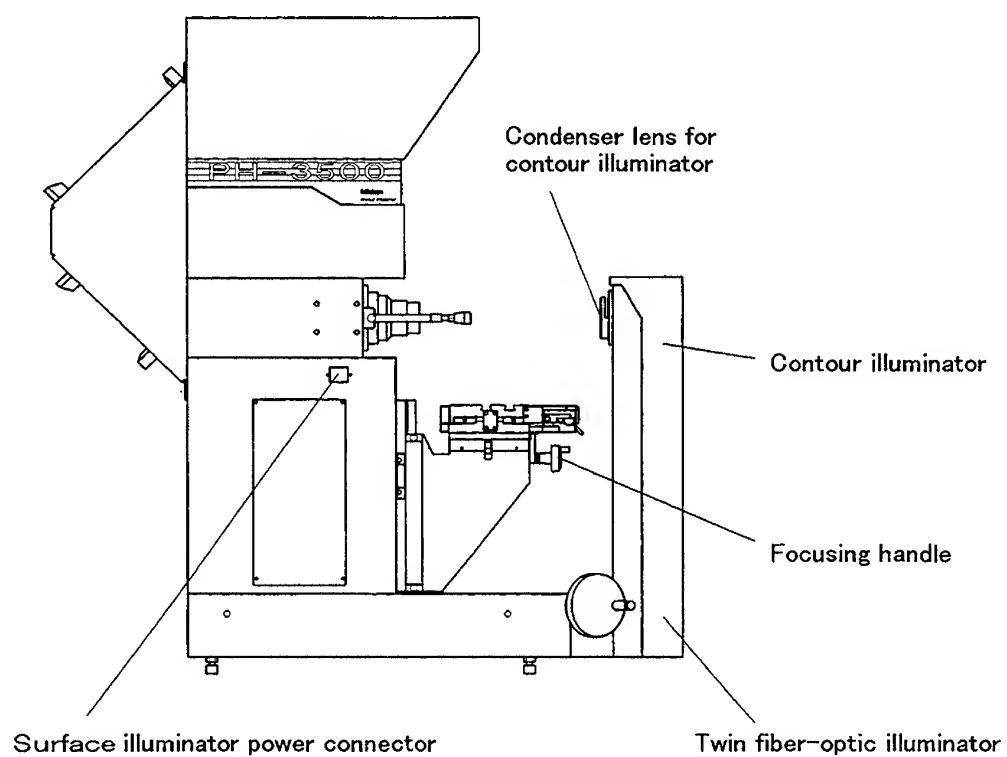
1.3.2

Right side view



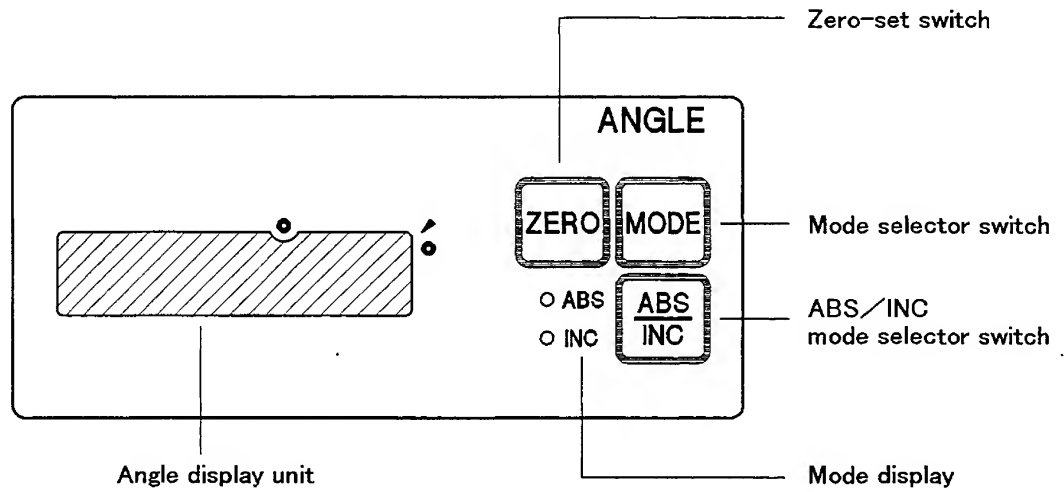
1.3.3

Left side view

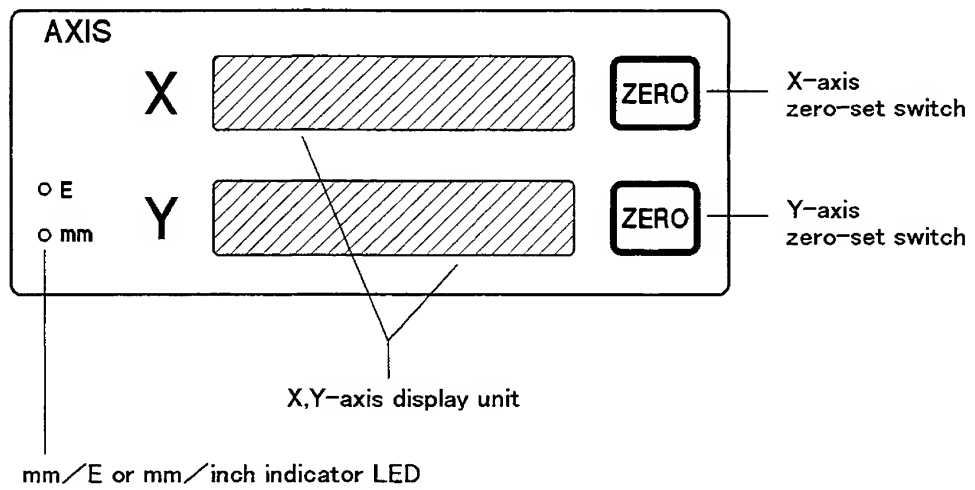


1. OUTLINE

1.3.4 Angle counter unit (front)



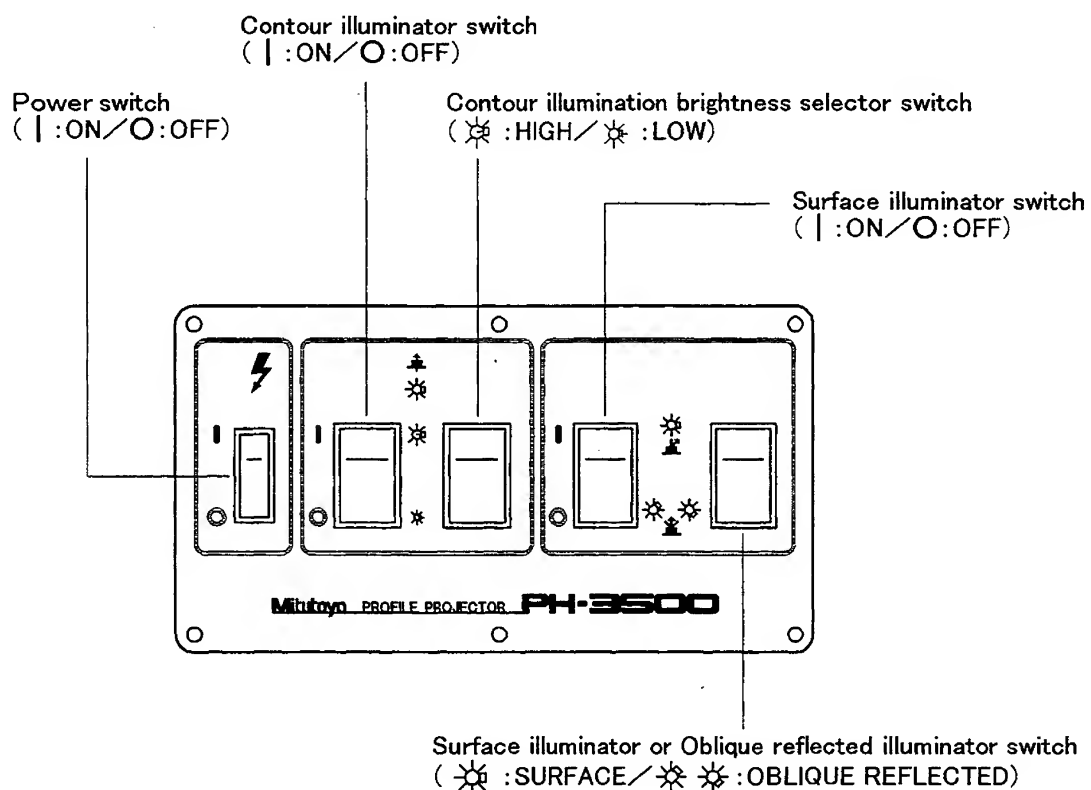
1.3.5 X, Y-axis counter unit (front)



1. OUTLINE

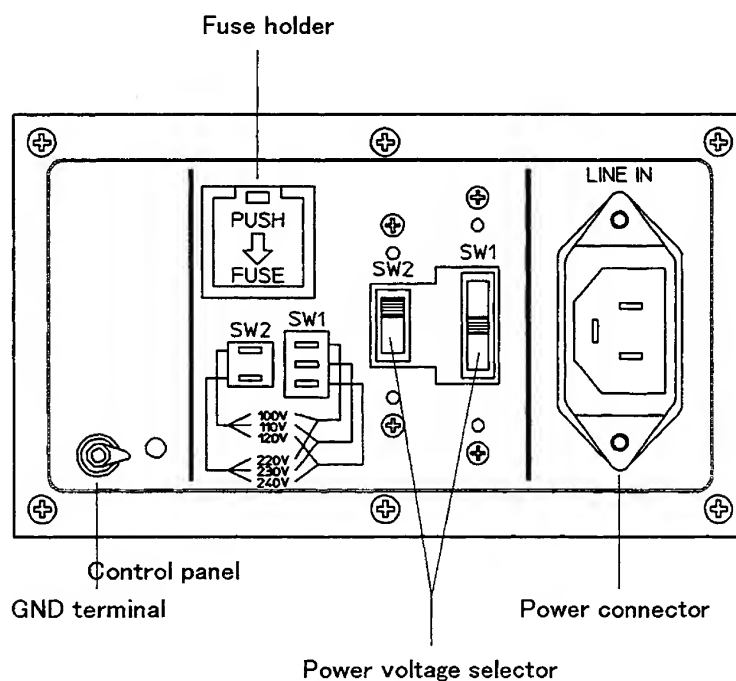
1.3.6

Control panel (front)



1.3.7

Power panel (rear)



1. OUTLINE

MEMO

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.1

Unpacking

Described in the following is how to unpack the PH-3500.

Note 2.1 1. To unpack, a nail puller, scissors, cutter, and an Allen key are necessary. Prepare them beforehand.

- Procedure

Step 1: Remove the nails using a nail puller, and open the package box of this profile projector.

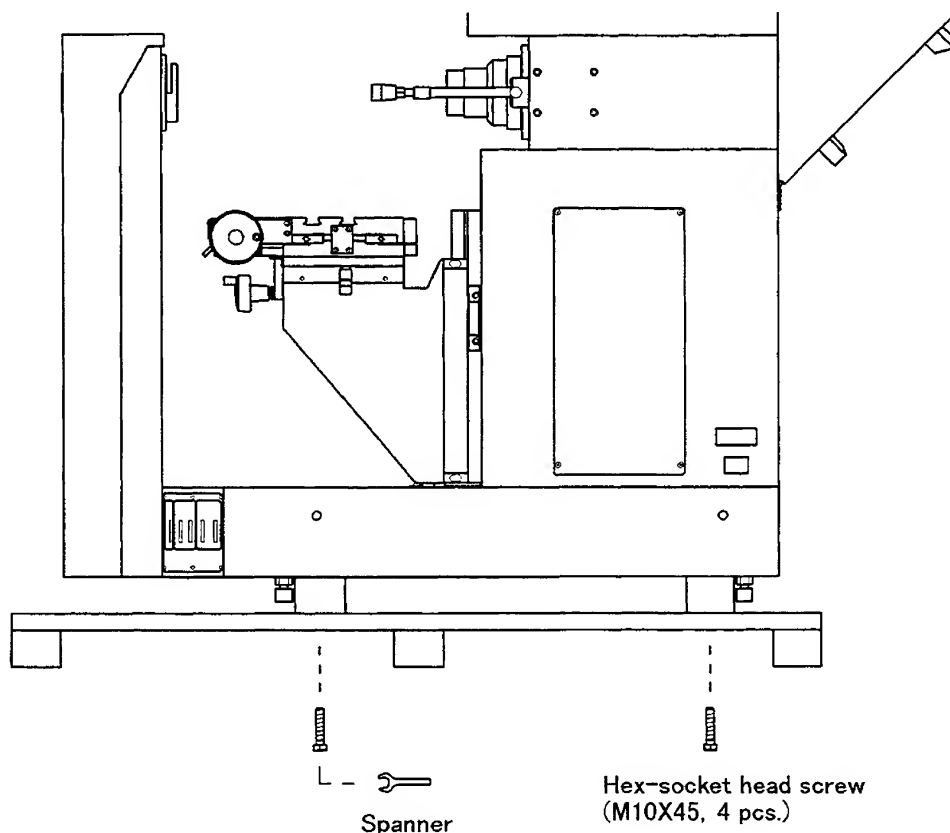
Step 2: Remove the metal-film wrapping using the scissors and cutter.

Step 3: Remove the vinyl cover using the scissors and cutter.

Note 2.2 1. Confirm that the main unit does not have a significant fault or distortion.

Step 4: Separate the standard accessory box and surface illuminator box from the main package.

Step 5: Remove the four bolts that secure the main unit with the base frame using an monkey spanner.



2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

Step 6: Remove the cushion protecting the protractor screen.

Step 7: Open the standard accessory box and check the supplied accessories.

Item	Quantity	Check
Lens set 10X	1	
Halogen lamp 24V 150W	2	
Halogen lamp 24V 200W (Twin fiber)	1	
Cap	4	
Power cord	1	
Warranty cord	1	
Spare fuse	1	
Vinyl cover	1	
Operation Manual	1	

Step 8: Repair parts

Part No.	Name	Quantity	備考
515530	Halogen lamp	2	Contour illuminator
12AAA637	Halogen lamp	1	Twin fiber illuminator
512467	Spare fuse	1	
358191			
510188			
384211			
515530	Halogen lamp	1	surface illuminator (option)

Step 9: Open the accessory box for the surface illuminator and check the contents. (option)

Item	Quantity	Check
Surface illuminator	1	
Set screws for mounting the surface illuminator	2	

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.2

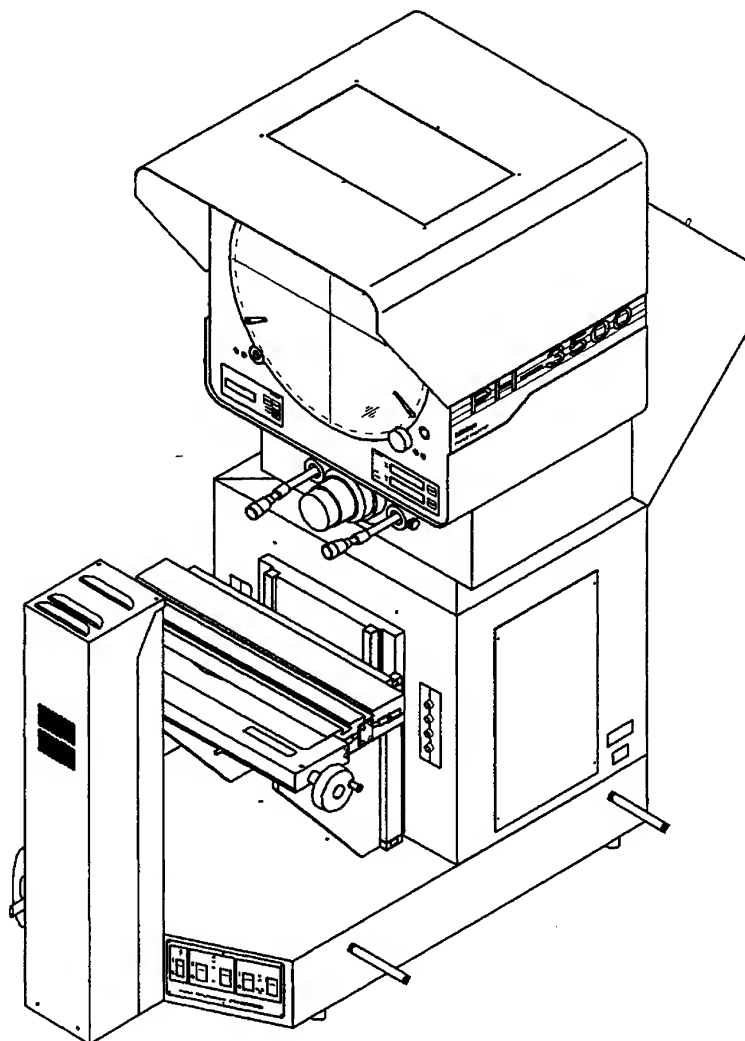
Setup

Set up the profile projector while observing the following points.

2.2.1

Carrying—in

The PH—3500 have been fully adjusted at the factory, therefore take special care when handing and setting up the projector so that no part of the projector is subjected to impact or vibration. Since the projector may weigh as much as 150kg, four people are required to carry it. Be sure to use the attached handles on both sides of the projector for carrying it. Never apply pressure to the control panel, microstage or other important parts.



2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.2.2

Environmental conditions

The following precautions must be taken for setup site selection:

- **Vibration**

The precision components of the projector will go out of adjustment if they are subjected to prolonged vibration, resulting in deterioration of measurement accuracy. If vibration is present at the setup site, take necessary vibration-reduction measures, such as laying a vibration damping rubber pad under the projector.

- **Dust**

Airborne dust will coat the optical parts and affect the precision mechanical parts of the microstage, causing wear and damage. The projector environment should therefore be as dust-free as possible.

- **Light**

Glare on the screen makes viewing difficult. Direct sunlight can cause deformation of the projector due to thermal expansion, which will affect measuring accuracy. Therefore the projector should be positioned so it does not face windows or room lights. It should be shaded if placed near a window.

- **Ambient temperature**

Temperature and humidity requirements for operating this projector are 0°C~40°C and 20%~80% respectively. However, avoid installing this projector where steep temperature change or high humidity may be present. This will be detrimental to the measurement accuracy.

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.2.3

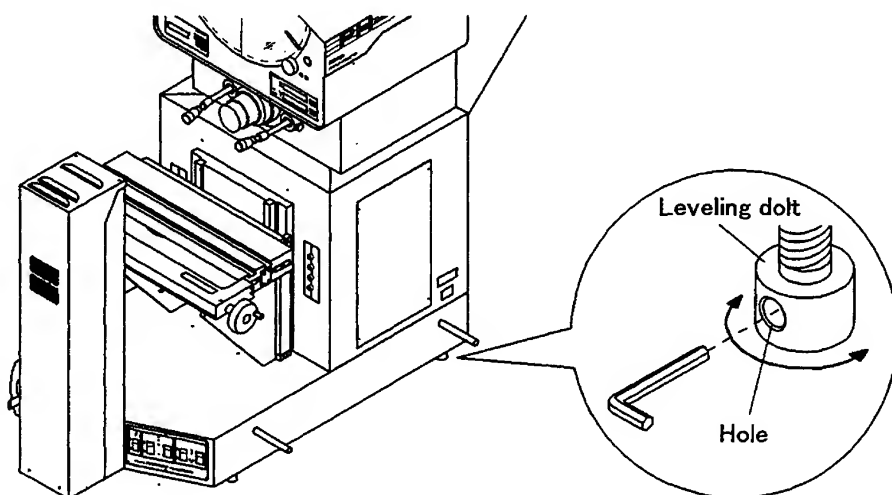
Installation

Observe the following points while installing the profile projector.

(1) Installation of the main unit

This profile projector is so heavy that it should be placed on something as strong as a sturdy steel desk.

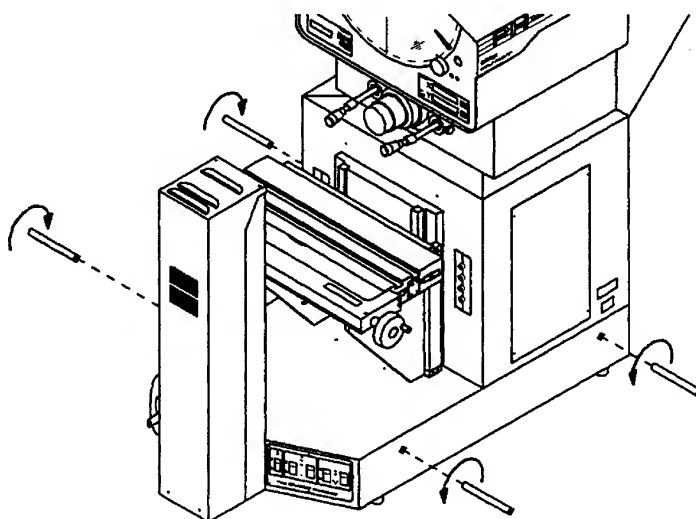
If the main unit is shaky or not level, use the leveling bolts located on the bottom of the main unit to level it.



Step 1: Adjust the main unit level with the leveling bolt.

(2) Removing the carrying handles

After setup, remove the carrying handles and cover the screw holds with the supplied hole caps.



2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.3

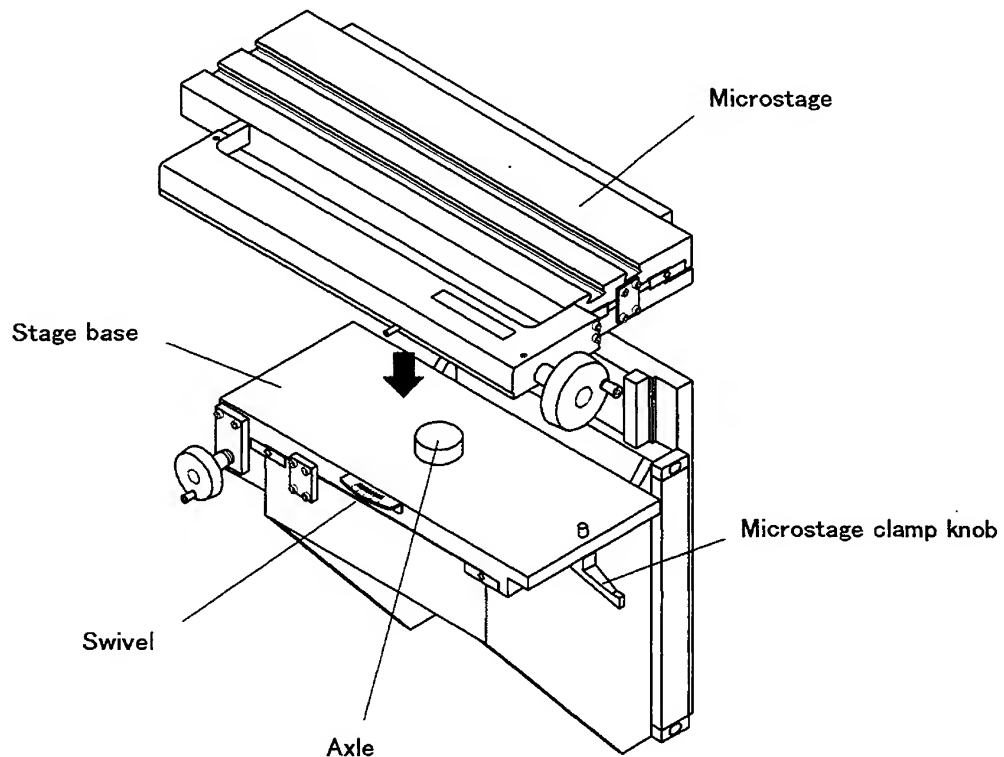
Assembly

The assembly procedure of the profile projector is explained below.

2.3.1

Mounting the microstage

- (1) Mount the microstage on the stage base.



Step 1: Gently place the microstage onto the axle protruding from the stage base.

Step 2: Fasten the microstage clamp knob located under the stage base by hand.

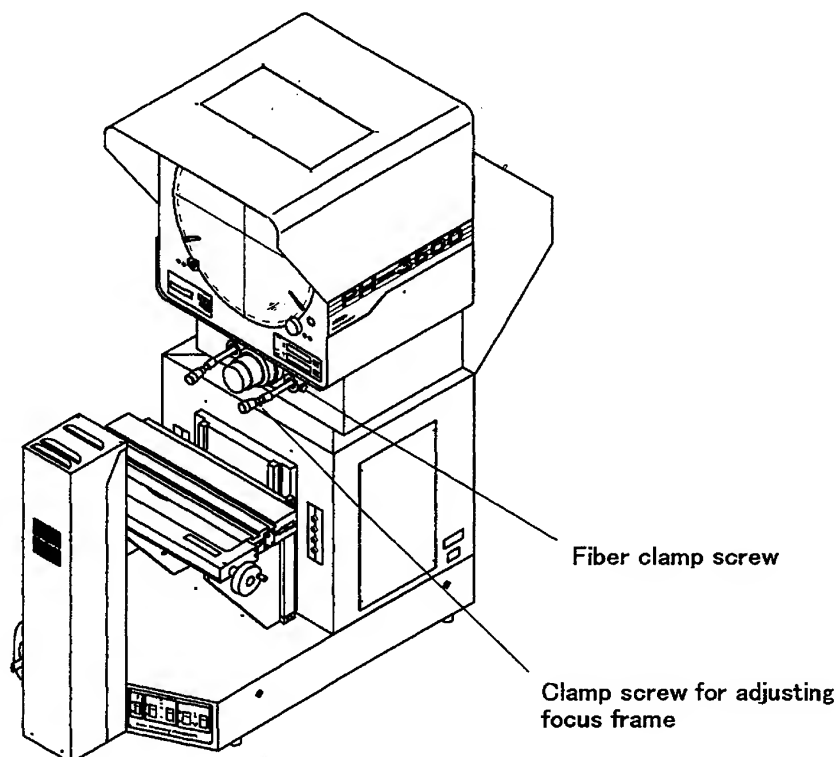
- Note 2.3**
1. The properly set microstage can swivel up to a maximum of 10° in both the clockwise and counterclockwise directions. Check if this swivel is smooth in both directions manually after loosening the microstage clamp knob.
 2. If the microstage movement is not normal or smooth, redo the mounting of the microstage from the beginning.

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.3.2

Installation of the optical fiber illumination unit (oblique reflected illumination unit)

The unit is pre-installed in the main body



- Step 1:** The length of two optical fibers out from the main body can be adjusted as desired. Also the optical fibers can be bent so flexibly that their lighting position can be easily adjusted according to a workpiece shape and position. Clamp them by the fiber clamp screw after their position are fixed.
- Step 2:** Focus of the optical fiber light can be adjusted by pushing or pulling the adjusting focus frame. Clamp the frame by the screw after adjustment is complete.

Magnification of the lens	5X	10X	20X	50X
Max diameter can be measured	ϕ 285mm (11.2")	ϕ 285mm (11.2")	ϕ 115mm (4.53")	ϕ 30mm (1.18")

- Max diameter can be measured when the optical fiber illumination unit is removed.

Magnification of the lens	5X	10X
Max diameter can be measured	ϕ 385mm (14.96")	ϕ 340mm (13.38")

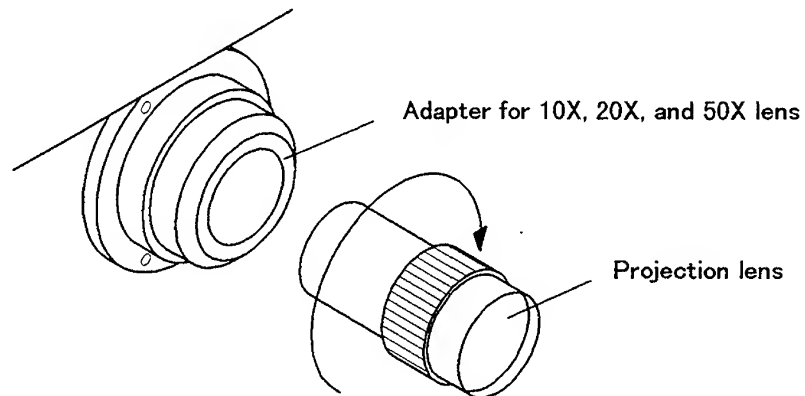
2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.3.3

Mounting the lens

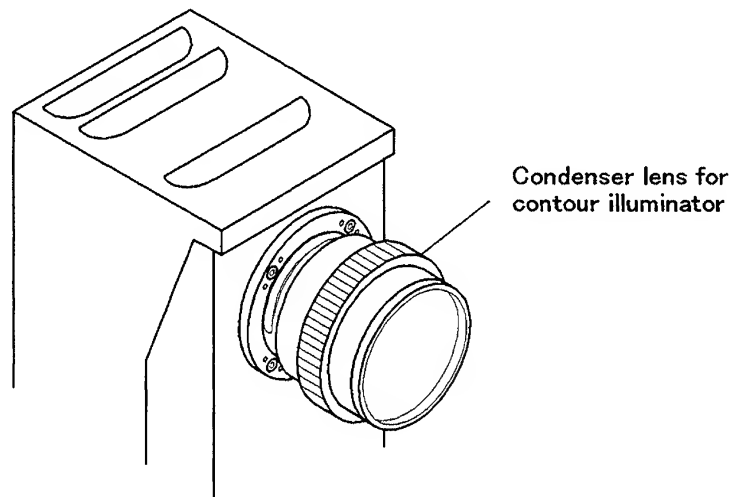
In mounting the projection lens, move the microstage up and down as required to allow room for the lens.

Step 1: Screw-in the projection lens into the lens mount as far as it can go.



Note 2.4 1. This profile projector is equipped with a standard adapter commonly used for 10X, 20X, and 50X, magnification projection lenses. If you use the 5X magnification lens, remove the adapter.

Step 2: Select a condenser lens for counter illumination, which matches the magnification of the projection lens, and insert it firmly into the lens mount located at the front of the contour illuminator unit.



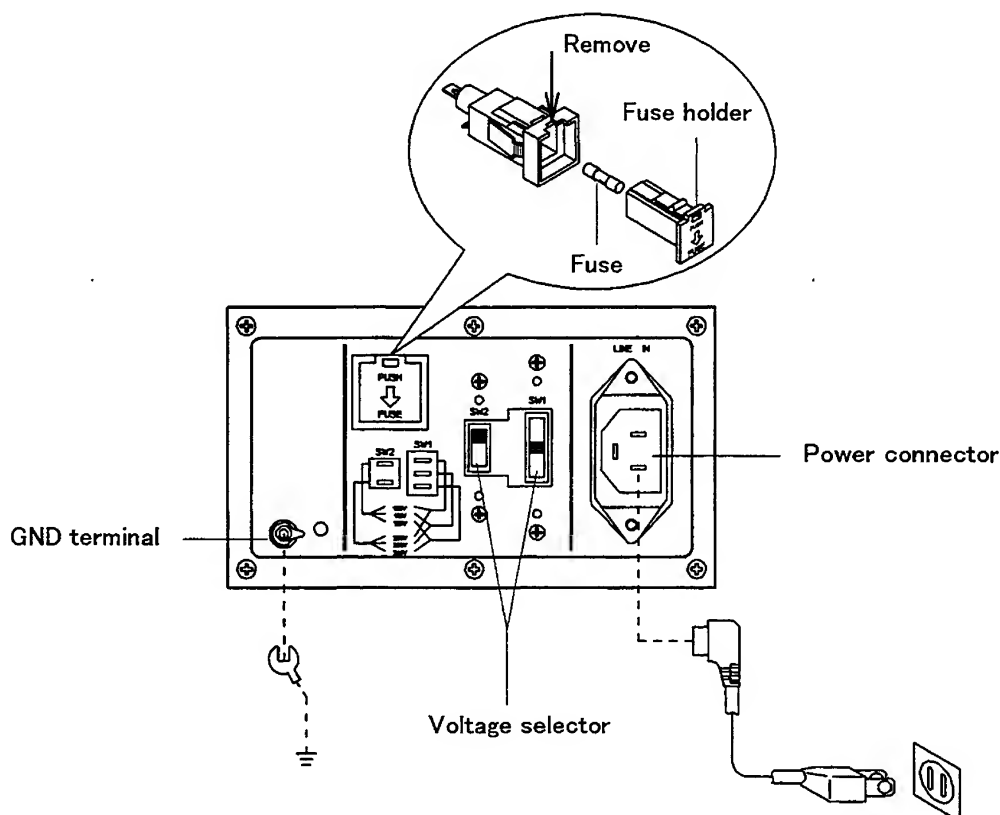
Note 2.5 1. No condenser lens is needed for contour illuminator when using a 10X or 20X projection lens.

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.3.4

Setting the power voltage

Take out the fuse holder on the main unit rear panel and replace the fuse a new one as follows.



- Step 1: Inserting a watchmaker's screwdriver in the slot on the upper side of the fuse holder case press it down and the fuse holder comes out of the case.
- Step 2: Pull out the fuse from the holder and replace a new one.
- Step 3: Inset the fuse holder in the case until it clicks.

2.3.5

Connecting the power cord

Connect the power cords of the main unit and peripherals such as the external counters.

- Step 1: Turn off the main switch.
- Step 2: Connect the power cord to the power connector.
- Step 3: Ground the GND terminal.

Note 2.6 1. Use the power cord supplied with the projector. If the provided AC plug does not have a grounding pin or if a 2P-3P adapter is used on a 3-prong AC plug, use the GND terminal for grounding.



2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.4

Initial Check

Even though the profile projector has been strictly adjusted at the factory and strict measures have been applied to its transportation, for further safety please check the following functions and performance.

2.4.1

Function Check

(1) Electrical component connectors

Make sure that the power cord, input connector, voltage selector, power switch, and GND terminal are securely connected.



Note 2.7 1. Before checking cables, make sure that all switches are turned OFF.

(2) Main switch (Power switch) ON—OFF

- Does the switch operate normally?
- Does the pilot lamp light up?
- Does the fan motor operate?

(3) Countor illuminator and surface illuminator switches

(Surface illuminator is optional)

Contour illuminator switch : ON→OFF, HIGH→LOW

Twin fiber illuminator : ON→OFF

Surface illuminator switch : ON→OFF (option)

- Do the switches operate normally?
- Does the brightness change normally?

(4) Focusing knob/Table elevation wheel

Check if there is any abnormal play or sound when the table is operated.

(5) Microstage

Turn the microstage fine feed knob and check if there is any abnormal play or sound in the full stroke range of the microstage travel.

(6) Counter

- Check if the indication lamp of the angle, X,Y-axis counter lights and if it counts correctly.
- Check if the indication lamp of the external counter lights and if it counts correctly.

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

(7) Projection screen

- Is the screen glass clean and free of scratches?
- Do the screen rotation knob, clamp and chart clips work correctly?

(8) Projection lens mount and condenser lens mount.

Check if there is any abnormal stiffness in the screws.

(9) Twin fiber illuminator and surface illuminator (option) control knob

Check if there is any abnormal stiffness in the screws.

(10) Other

Check the other parts of the main unit and peripherals for normal appearance and functions.

<p>Note 2.8 1. If there is any abnormality found in the above described checks, refer to 3.8 or chapter 4 for remedies.</p>

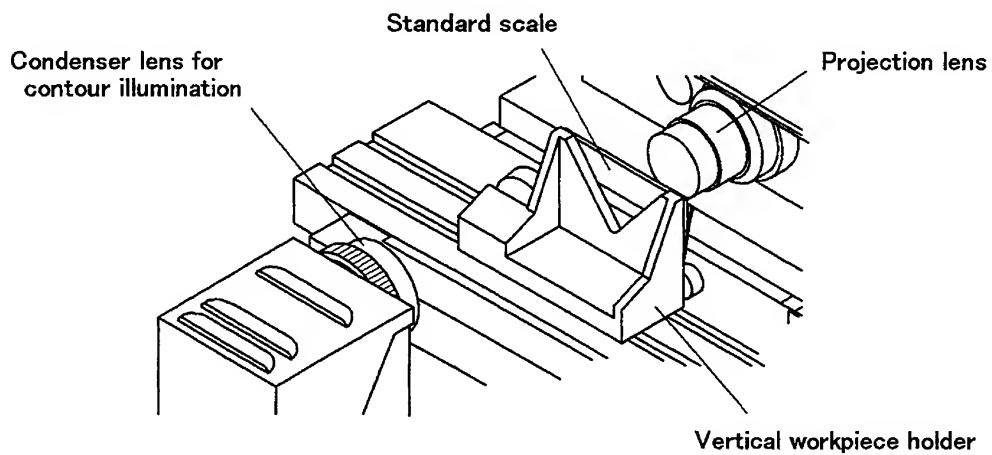
2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.4.2

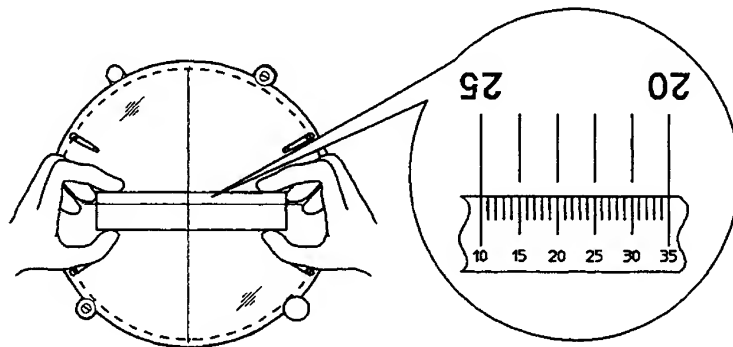
Performance check

(1) Checking the magnification accuracy

Step 1: Mount the projection lens and corresponding condenser lens for contour illumination.

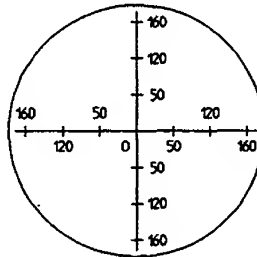


Step 2: Using a vertical workpiece holder (option), etc., place a standard scale (optional accessory, No. 172-116) on the microstage. Project the image of this standard scale onto the screen and measure it using a reading scale (option) as follows.



2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

Step 3: Measure the projected image of the standard scale on the screen using a reading scale. Take measurements at three at three reference points (50mm, 120mm, 160mm) in four or more radial directions along the cross-hair lines on the screen.



Step 4: Calculate the magnification error using the following formula:

$$\Delta M = \frac{L - Q M}{Q M} \times 100\%$$

ΔM : magnification error
 L : measured length of the standard scale.
 Q : Length of the standard scale
 M : magnification of the projection lens.

- The magnification error is specified as $\pm 0.1\%$ or less for contour illumination, and the tolerance for each measured point is tabulated below.
 (If the magnification error for contour illumination falls within the tolerance, that for surface illumination will also fall within the specified tolerance of $\pm 0.15\%$)

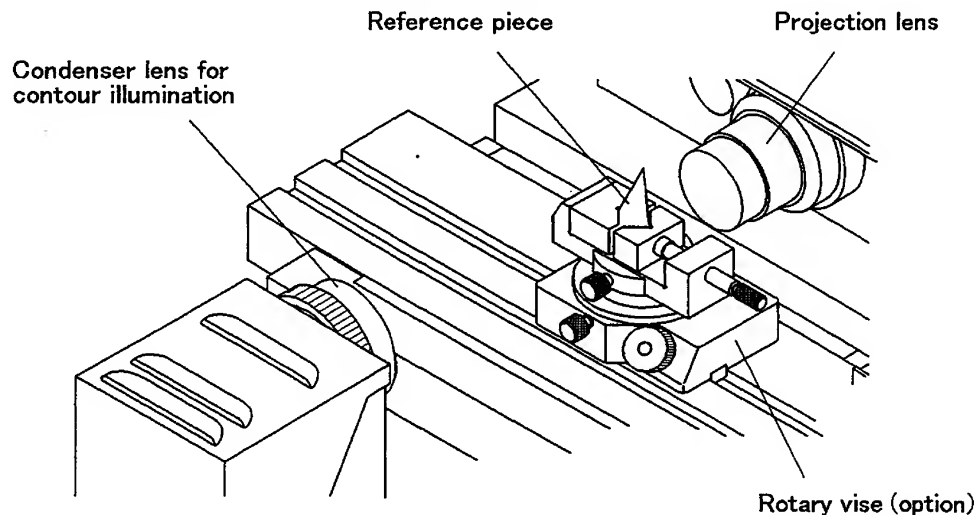
Measured point (on the reading scale)	Tolerance	Permissible range
50mm (1.969")	$\pm 0.05\text{mm}$ ($\pm .002"$)	49.95–50.05mm (1.967–1.971")
120mm (4.724")	$\pm 0.12\text{mm}$ ($\pm .0047"$)	119.88–120.12mm (4.7193–4.7287")
160mm (6.693")	$\pm 0.16\text{mm}$ ($\pm .0063"$)	159.84–160.16mm (6.2929–6.3055")

A positive error, where ΔM is a positive value, means that the measured length L is large than the normal size ($Q \times M$); and vice versa for a negative error.

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

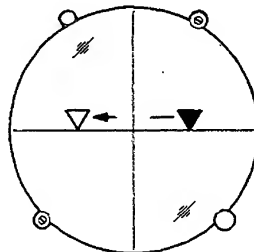
(2) Checking the magnification travel direction

- Step 1:** Mount the least powerful of the projection lenses and select the condenser lens that matches the magnification of the projection lens.
- Step 2:** Place a reference piece on the microstage using such as a rotary vise (option), and project its image on the screen.



- Step 3:** Set the protractor screen reference line to "0".
- Step 4:** Move the microstage along the Y-axis (back and forth), and the edge of the reference piece with the horizontal cross-hair line.
- Step 5:** Move the microstage along the X-axis (left and right), and confirm that the edge of the reference piece is aligned with the horizontal cross-hair line over the entire length of microstage X-axis travel.

If the projected image of the reference piece deviates from the cross-hair line, the mounting of the microstage or straightness of the microstage may not have been correct. Refer to 3.1 for redoing the mounting and another check. If the deviation remains after it is remounted, contact Mitutoyo.



Note 2.9 1. The projected image by this profile projector is inversely erect, laterally inverted image.

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

(3) Checking the microstage feed error

If the microstage moves normally in check items (5) in 2.4.1, checking of feed error over a 5mm travel may be sufficient, in this checking, many factors must be taken into consideration, including environmental conditions and alignment error.

Step 1: By referring to the descriptions in (1) Checking the magnification accuracy, place an optional standard scale, etc., whose exact dimensions are known, on the microstage using a vertical workpiece holder (option). Project the image of the standard scale on the screen.

Step 2: Align the edge of the scale image with a horizontal hair-line on the screen by operating the microstage feed knob and table elevation wheel.

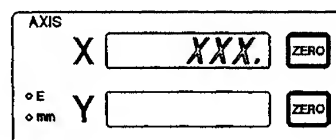
Step 3: Reset the external counter to zero.

Step 4: Move the microstage using the microstage feed knob and table elevation wheel, and read the displacement on the screen by fitting a reading scale on the screen.

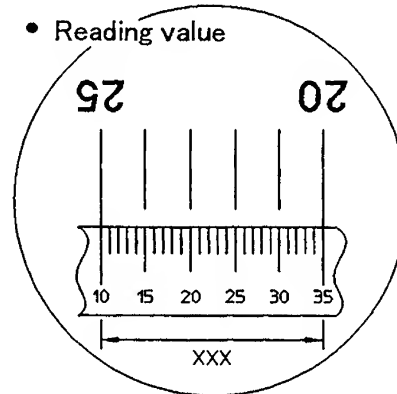
Then check the table feeding accuracy by comparing the counter value at the external counter with that from the following formula.

$$\frac{\text{Reading value XXX}}{\text{Magnification}} \doteq \frac{\text{Counter value}}{\text{XXX}}$$

• Counter value



• Reading value



Note 2.10 1. This feeding accuracy checks must be performed on both sides of the vertical and horizontal hair-lines, and in both forward and backward directions.

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

(4) Checking the resolution (in contour illumination mode)

Check the image resolution with the following procedure.

Step 1: Mount a projection lens and the condenser lens which corresponds to the magnification of the projection lens.

Step 2: Place a workpiece on the microstage and project its image on the screen. Move the workpiece position using the table elevation wheel or microstage feed knob along the full microstage cross-stroke range to ensure that the image is clear over the entire screen without any obscured regions (especially on the screen edge).

<p>Note 2.11 1. When there is any abnormality found in the above checks, refer to section 3.8.</p>

2. UNPACKING, INSTALLATION, ASSEMBLY, INSPECTION AND ADJUSTMENT

2.5 Adjustment

2.5.1 Centering the protractor screen

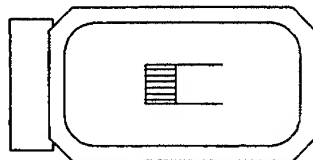


Note 2.12 1. This adjustment requires experience. Contact Mitutoyo for assistance.

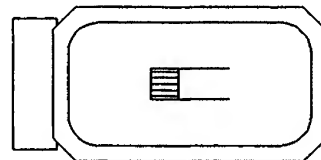
2.5.2 Adjustment of the direction of the filament

When attaching a lamp in the surface illuminator, it is necessary to adjust the direction of the filament as follows. (The surface illuminator is optional)

- Step 1: After the operation shown in 4.3.3 is complete, remove the condenser lens for surface illumination from its mount. (Refer also 2.3.3)
- Step 2: Mount the half-reflecting mirror which corresponds to the magnification of the projection lens.
- Step 3: Turn on the surface illuminator.
- Step 4: Move the surface illuminator unit so the filament image is projected on the half-reflecting mirror (Refer to 3.3.2). By moving the sleeve, adjust the filament direction so that the projected image on the half-reflecting mirror is straight.



OK



NG

- Step 5: When the adjustment is completed, clamp the sleeve.

3. OPERATION

3.1

Projection Lens Selection

Select the appropriate projection lens magnification according to the required field of view, measuring method and accuracy requirements.

When changing the magnification, use a projection lens and condenser lens/half-reflecting mirror both of which correspond to the same magnification.

Name Magnification	Projection lens	Condenser lens for contour illumination	Half-reflecting mirror	Condenser lens for contour illumination
5X				
10X				
20X			Built-in the projection lens	Common to 10X, 20X, 50X Built-in the surface illuminator
50X			Built-in the projection lens	

- Note 3.1
1. Move the microstage up and down or to the right and left as required to allow room for mounting / demounting the lenses.
In handling the lenses, take sufficient care so as not to damage the lenses.
 2. When using 5X projection lens, pay special attention not to clash it against the workstage while the stage is elevated up in Y-axis direction.



CAUTION

- After being turned off, the projection lens remains very hot for some time. Take care not to burn your fingers.
Do not attempt to replace the lens before it has cooled sufficiently.

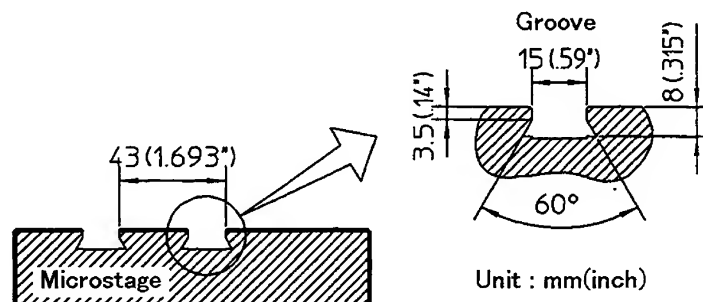
3. OPERATION

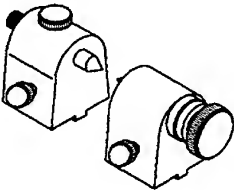
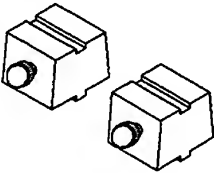
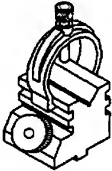
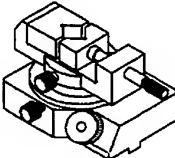
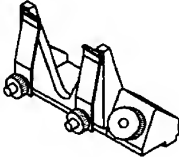
3.2

Positioning the Workpiece

Three parallel grooves are provided on the microstage surface at intervals of 43mm. With these grooves, position a workpiece on the microstage using a special fixture that conforms to the workpiece feature.

There are various types of dedicated fixtures provided for this profile projector as follows.



Model name	Appearance	Purpose
Center support (No.172-142)		Used to position a cylindrical workpiece which has two punched holes at both sides.
Riser (No.172-143)		Used to offset the center support.
V-block (No.172-234)		Used to position a normal cylindrical workpiece.
Rotary vise (No.172-144)		Used to position a normal cylindrical workpiece.
Vertical workpiece holder (No.172-132)		Used to hold a thin workpiece.

3. OPERATION

3.3

Projecting Methods

When you turn on the main switch (power switch), the pilot lamp in the switch lights up. When you turn on the contour illuminator switch, the contour illumination lamp turns on, and likewise for the surface illuminator switch.

The brightness of the contour illumination can be adjusted by the contour illumination control switch to the brightest level at the HIGH position, and to one less bright at the LOW position.

3.3.1

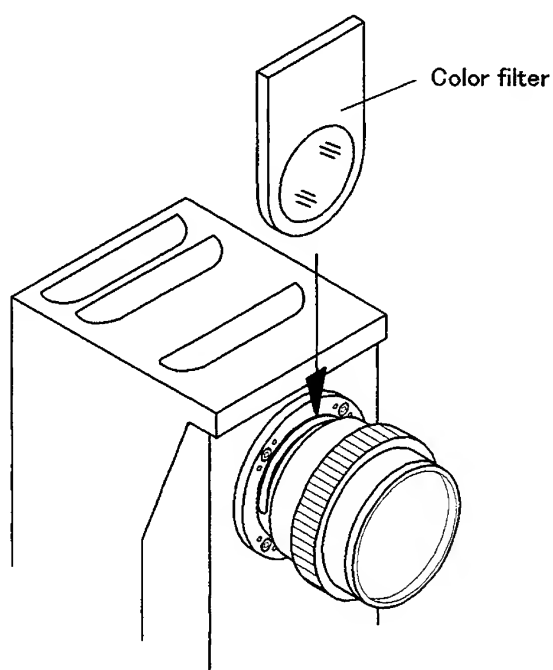
Projection by contour illumination

The surface image of the workpiece is projected onto the screen. Be sure to use the condenser lens which corresponds to the magnification of the projection lens to be used.

Operation	Description	Projection screen
	Position the workpiece so it intersects the optical axis of the projection lens (which is collinear with the axis of the contour illumination).	

- When using a color filter

Insert an optional color filter (No. 172-286) into the behind the condenser lens mount.



3. OPERATION

3.3.2

Projection by surface illumination

With the use of a half-reflecting mirror, it is possible to project the workpiece surface image on the screen. (The surface illuminator is optional)

- When the 5X or 10X projection lens is used :

Operation	Description	Projection screen
	Position the workpiece so it intersects the optical axis of the projection lens. (The optical axis is collinear with the axis of a beam that comes from the surface illuminator and reflects on the half-mirror). When the 5X or 10X projection lens is mounted, this half-reflection mirror is attached to the front of the projection lens.	

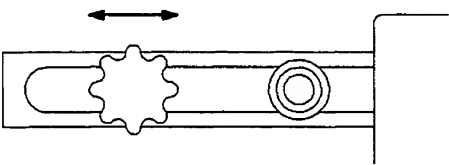
- When the 20X or 50X projection lens is used :

Operation	Description	Projection screen
	Position the workpiece so it intersects the optical axis of the projection lens. (The optical axis is collinear with the axis of a beam that comes from the surface illuminator and reflects on the half-mirror). Both the 20X or 50X projection lens have a half-reflection mirror inside the tube.	

3. OPERATION

- Adjusting the position of the surface illuminator (Option)

Adjust the position of the surface illuminator unit with the following procedures.

Procedure	Operation	Description
Step 1		Loosen the knob that is securing the surface illuminator to allow a freedom motion of the bracket.
Step 2		For each case of the 5X, 10X, 20X, and 50X magnifications, adjust the surface illuminator position so that the projected image is clear over the entire range of the projection screen.

- Adjusting the light beam (Option)

The method to adjust the light beam from the surface illuminator varies depending on the magnification of the condenser used. The methods are as follows.

Procedure	10X·20X·50X	5X
Operation		
Description	Thickness of the light beam from the surface illuminator can be adjusted by turning the lens tube so that it goes in and out of the lens mount. Perform this adjustment according to the magnification (10X,20X,50X) in order for the projected image to be the brightest.	When you use a 5X lens, remove the clamp screw and replace the condenser lens for 10X,20X,50X with that for 5X magnification.

3. OPERATION

3.3.3

Projection by both the contour and surface illumination (Option)

Both contour and surface images of a workpiece are projected onto the screen.

Operation	Description	Projection screen
	Position the workpiece so it intersects the optical axis of the projection lens. (The optical axis is collinear with the axis of a beam that comes from the surface illuminator and reflects on the half-mirror).	

3.3.4

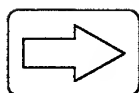
Calibrating the angle counter

To always obtain a correct measurement, perform the following calibration on the angle counter before using the PH-3500 for the first time.

1. Turn the power switch to "ON" while holding down the **【ABS/INC】** key.
(Counter displays 0".)
2. Align the reference line on the protractor with the "0" line on the index plate, then hold the **【ZERO】** key for about 3 seconds. (Counter is zero-set in the ABS mode.)
3. Using the screen rotation knob rotate projection screen frame so that the angle counter positively counts.

Rotate the projection screen frame by a full turn until the reference line aligns again with the "0" line index plate.
4. Press the display unit selector and zero-set key at the same time to execute calibration.
(The calibrated counter displays 360° 00' or 360.00° .)

Hereafter, the calibration value thus established will not be cleared even when the main power of the PH-3500 is off.



Calibration cannot be achieved by rotating the projection screen frame in the direction the angle counter counts negatively.



注意

Should the counter display after calibration not indicate 360° 00' or 360.00° , contact Mitutoyo.

3. OPERATION

3.4

Preparation for Measurement (Positioning and Focusing)

Described in the following is the procedure starting from the positioning of the workpiece image to the focusing on the projection screen.

Procedure	Operation	Description
Step 1	Refer to 3.1	Select the appropriate projection lens magnification according to the required field of view, measuring method and accuracy requirements.
Step 2	Refer to 3.2	Select the appropriate fixture from the options according to the shape of the workpiece.
Step 3	Refer to 3.3	Select the appropriate projection method according to the required field of view, measuring method, and accuracy requirements.
Step 4		Adjust the workpiece position on the microstage so that the workpiece intersects the light axis of the projection lens using the table elevation wheel and microstage coarse and fine feed knobs.
Step 5		Position the workpiece image on the screen so that the best position or angle is given for the measurement. Because the microstage is equipped with a swivel function, it can swivel up to $\pm 10^\circ$ within the horizontal plane, which makes positioning the workpiece much easier.
Step 6		Focus onto the workpiece by shifting the microstage back and forth with the focusing wheel.

3. OPERATION

3.5

General Measurement and inspection

This profile projector has a wide range of measuring applications. Select a measuring method that suits for the shape, size, quantity of the workpiece and the measuring purpose and requirements. Explained below is how to measure/inspect a workpiece without using a linear scale or a counter unit.

3.5.1

Dimensional measurement using a scale

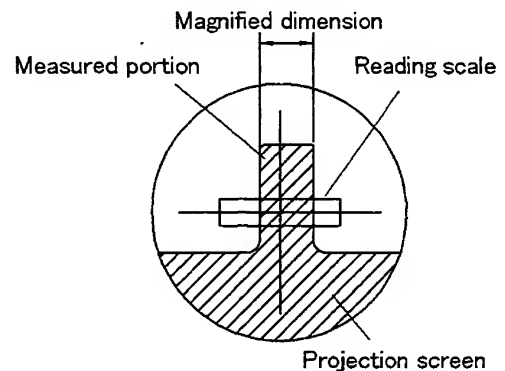
After completing the procedure as shown in 3.4, place the scale on the screen and measure the enlarged image. Divide the measurements by the magnification of the projection lens to determine the actual dimensions.

(Example)

Measured value on the screen : 150mm

Projection lens magnification : 10X

Actual dimension of the workpiece : 15mm



- The optional reading scale is ideal for this type of measurement because the graduated surface of the scale fits on the screen glass, providing parallax-free measurement.

3.5.2

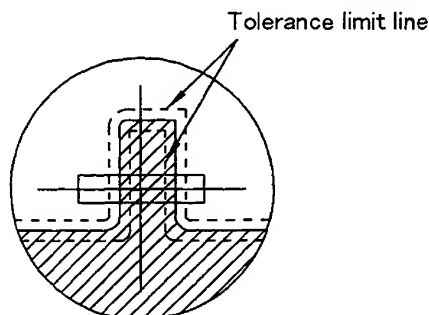
Comparison with an overlay chart

After completing the procedure as shown in 3.4, perform measurement and inspection of comparing the workpiece image with the standard overlay chart which is custom-made for the selected magnification. Use this method for measurement of shapes, multiple point and dimensions.

This method of measurement is suitable for checking a complicated part feature which cannot be inspected in a simple one-dimensional measurement.

Adding tolerance lines onto the standard overlay chart will improve inspection efficiency, since workpieces can be inspected with reference to these lines.

Standard charts can be made from the workpiece blue print, or the master workpiece image projected on the screen. Use transparent or semi-transparent tracing sheets(or film) to make them. For close inspection or for long-term storage, plastic tracing sheets are recommended because of their greater dimensional stability.



3. OPERATION

3.6

Measurement Using an External Unit

With an external counter unit connected to this profile projector, it becomes possible to perform a high-accuracy measurement by the use of linear scales incorporated in the microstage.

The following is the brief explanation of example measurement using an external counter connectable with the profile projector.

(1) Connection for each counter unit

Connector specifications of this profile projector are as follows. For each connector unit, refer to the applicable operation manual.

- Silver cable : from Linear Scale AT12-270 for X-axis data output, giving a resolution of 1 μ m.
- Black cable : from Linear Scale AT12-170 for Y-axis data output, giving a resolution of 1 μ m.

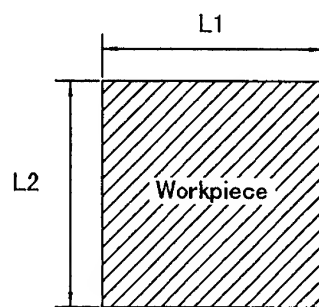
(2) Measuring procedure with each counter unit

For details, read the operation manual of each counter unit.

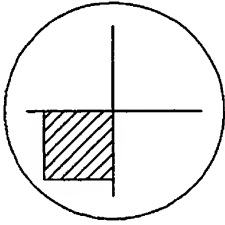




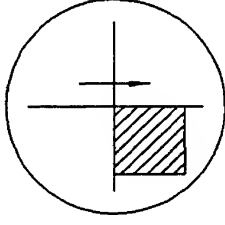
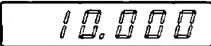
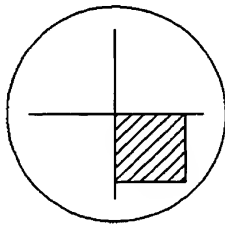

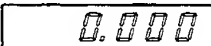
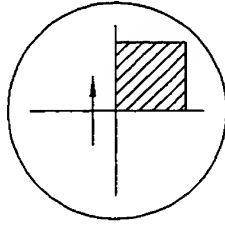

3.6.1

Built-in X, Y-axis counter

The measurement procedure of the dimension L1 and L2 on the workpiece drawn below is explained here.



3. OPERATION

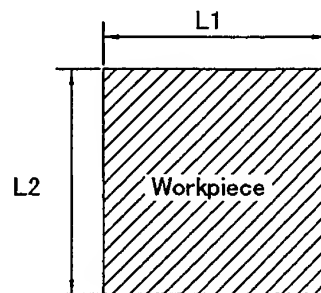
Procedure	Operation	Screen/Profile Projector	Counter operation/Display
Step 1	Prepare for measurement by referring to the procedure of 3.4. Position the workpiece so that the edge to be measured aligns with a cross-hair line on the screen. Focus on the workpiece.		
Step 2	Press the X-axis zero set button of the X,Y counter to zero-set the X-axis counter.		Counter  Display X 
Step 3	Move the microstage (or micrometer head) using the microstage feed knobs so that the other edge of the workpiece image aligns with the same cross-hair line on the screen. Dimension L1 can be counted as a X-axis displacement and displayed on the counter.		Display X 
Step 4	Press the Y-axis zero set button of the X,Y counter to zero-set the Y-axis counter.		Counter  Display Y 
Step 5	Move the microstage (or micrometer head) using the table elevation wheel so that the other edge of the workpiece image aligns with the same cross-hair line on the screen. Dimension L2 can be counted as a Y-axis displacement and displayed on the counter.		Display Y 

3. OPERATION

3.6.2

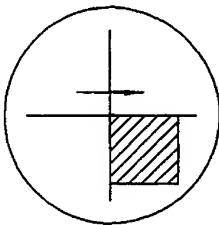

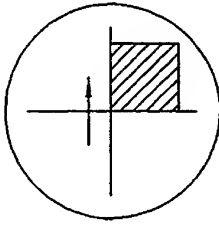

Measurement with a GEO-CHEK counter

The following explains how to connect the GEO-CHEK counter to the profile projector and the measuring procedures. The procedure is for measuring a sample workpiece which has dimensions of L1 and L2, as shown in the following diagram. For details of the measurement, refer also to the operation manual of the GEO-CHEK counter.



Procedure	Operation	Screen/Profile Projector	Counter operation/Display
Step 1	Prepare for the measurement by referring to the procedure of 3.4. Position the workpiece so that the edge to be measured aligns with a cross-hair line on the screen. Focus on the workpiece.		_____
Step 2	Zero-set the GEO-CHEK counter in the ABS mode.	_____	<p>Counter</p> <div> <div>X</div> <div>Y</div> <div>INC ABS</div> <div>ENTER</div> </div> <p>Display</p> <div> <div>0.000</div> <div>X</div> </div> <div> <div>0.000</div> <div>Y</div> </div>

3. OPERATION

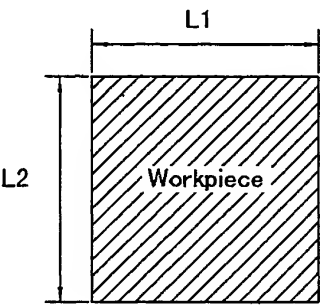
Procedure	Operation	Screen/Profile Projector	Counter operation/Display
Step 3	Move the microstage using the microstage feed knobs so that the other edge of the work-piece image aligns with the same cross-hair line on the screen. Dimension L1 can be counted as a X-axis displacement and displayed on the counter.		Display 
Step 4	Move the microstage using the table elevation wheel so that the other edge of the work-piece image aligns with the same cross-hair line on the screen. Dimension L2 can be counted as a Y-axis displacement and displayed on the counter.		Display 

3. OPERATION

3.6.3

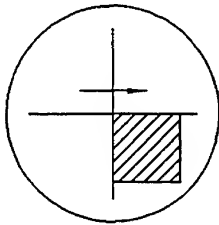

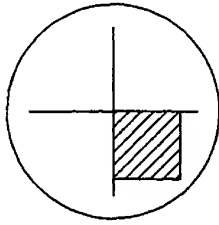


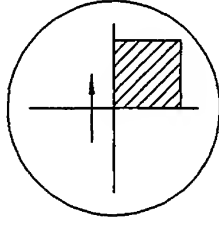

Measurement with a PM counter

The following explains how to connect the PM counter to the profile projector and the measuring procedures. The procedure is for measuring a sample workpiece which has dimensions of L1 and L2, as shown in the following diagram, using this profile protector, a PM counter and an Optoeye M2 counter. For details of the measurement, refer also to the operation manual of the each device.



Procedure	Operation	Screen/Profile Projector	Counter operation/Display
Step 1	Prepare for measurement by referring to the procedure of 3.4. Position the workpiece so that the edge to be measured aligns with a cross-hair line on the screen. Focus on the workpiece.		
Step 2	Zero-set the X-axis counter in the PM counter.		Counter Display

3. OPERATION

Procedure	Operation	Screen/Profile Projector	Counter operation/Display
Step 3	Move the microstage using the microstage feed knobs so that the other edge of the work-piece image aligns with the same cross-hair line on the screen. With this operation dimension L1 can be counted and displayed on the counter.		Display 
Step 4	Zero-set the Y-axis counter in the PM counter.		Counter  Display 
Step 5	Move the microstage using the table elevation wheel so that the other edge of the work-piece image aligns with the same cross-hair line on the screen. With this operation dimension L2 can be counted as a Y-axis displacement and displayed on the counter.		Display 

3. OPERATION

3.7

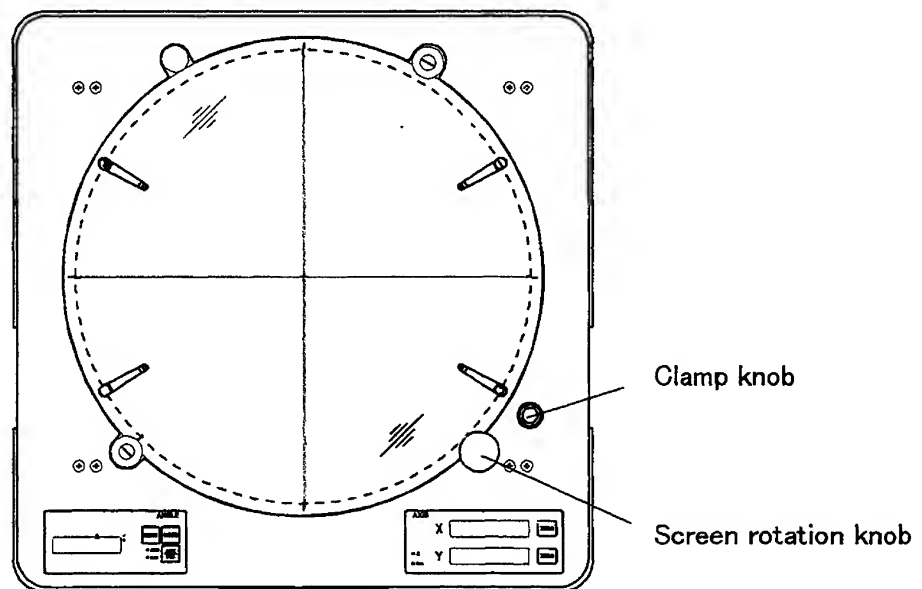
Angle Measurement

The following is an example of using the protractor screen and the rotary table for measuring angles.

3.7.1

Protractor screen

Loosen the clamp knob and use the rotation knob to turn the protractor screen.



Note 3.2 1. Always use the screen rotation knob to rotate the protractor screen. Other methods of screen rotation may cause an error in angle measurement.

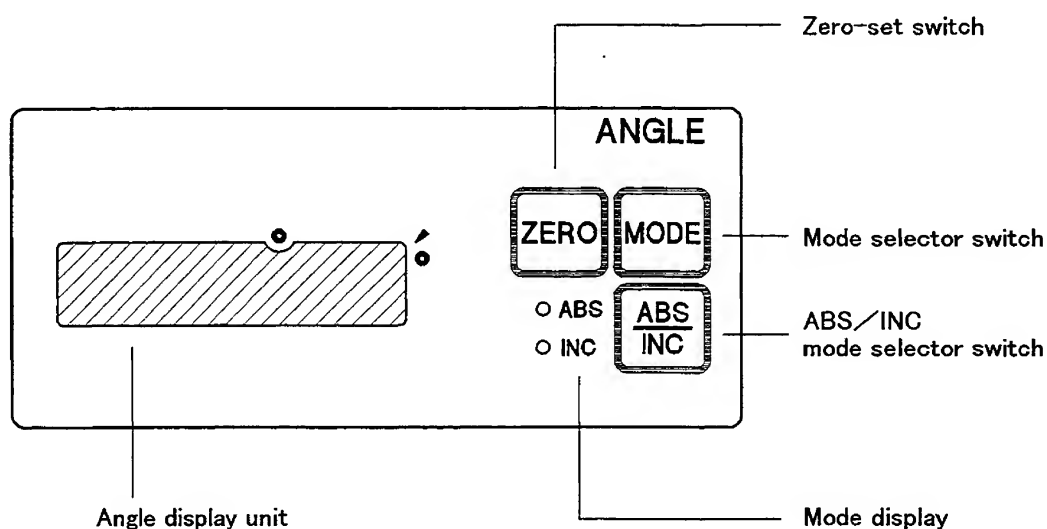
3. OPERATION

3.7.2

Angle counter

The angle counter has two measurement modes : ABS mode for absolute measurement and INC mode for comparative measurement. Use the [ABS/INC] key to select the mode. Pressing the [ZERO] key sets the counter to zero at any angular position. The range of angle display is $\pm 360^\circ$ (In ABS mode, up to $\pm 370^\circ$)

At power on, the counter is in ABS mode with 0 being displayed. The [MODE] key toggles the smallest unit of the angle counter between 0.01° and $1'$. (Initial setting is $1'$)



- Error display

The following table shows various error indications on the angle counter and the method of correction.

Error codes	Content	Remedy
E--0F	Where the protractor screen rotates over $\pm 360^\circ$ ($\pm 370^\circ$ in the ABS mode)	These error indications can be cleared by pressing the zero-set switch on the angle counter.
E--05	Where the rotation speed of the protractor screen exceeds 400mm/sec or the counter picks up some noise.	

3. OPERATION

3.7.3

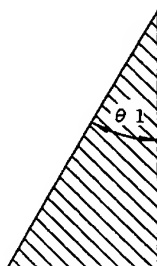
Measurement

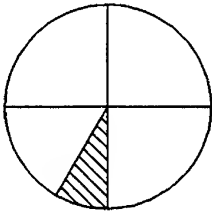


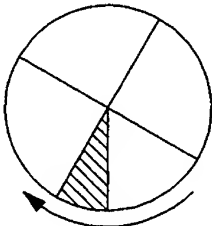

The following explains the angle measuring procedure.

(1) Measuring in ABS mode

- When using the protractor screen only

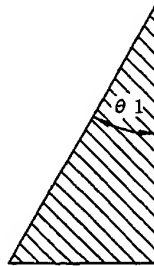
The following workpiece, which has a vertex of $\theta 1$, is to be measured.

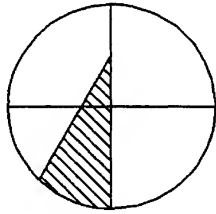



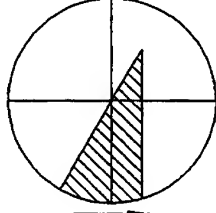
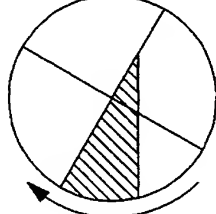
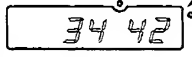


Procedure	Operation	Screen	Counter operation/Display
Step 1	Prepare for measurement by referring to the procedure of 3.4. Align the vertex of the angle to be measured with the intersection of the cross-hair lines, then rotate the protractor screen to align one edge of the angle with a cross-hair line. Set the angle counter to ABS mode and establish a datum on the edge by setting the counter to zero.		<p>Counter</p> <p></p> <p>Display</p> <p>● ABS ○ INC </p>
Step 2	Rotate the protractor screen to align the other edge of the angle with the same cross-hair line used in step 1. The measured angle is displayed on the angle counter.		<p>Display</p> <p>● ABS ○ INC </p>

3. OPERATION

- Measurement using both the protractor screen and microstage movement.
The following workpiece, which has a vertex of $\theta 1$, is to be measured.

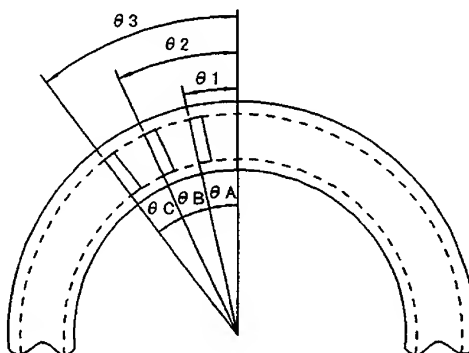




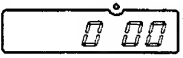
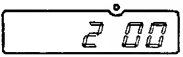


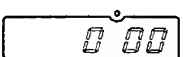
Procedure	Operation	Screen	Counter operation/Display
Step 1	Prepare for the measurement by referring to the procedure of 3.4. Align the vertex of the angle to be measured with the intersection of the cross-hair lines, then rotate the protractor screen to align one edge of the angle with a cross-hair line. Set the angle counter to ABS mode and establish a datum on the edge by setting the counter to zero.		<p>Counter</p> <div>   </div> <p>Display</p> <div> <p>● ABS ○ INC</p>  </div>
Step 2	Feed the microstage in the X-axis direction as shown on the right.		
Step 3	Rotate the protractor screen to align the other edge of the angle with the same cross-hair line used in step 1. The measured angle is displayed on the angle counter.		<p>Counter</p> <div> <p>● ABS ○ INC</p>  </div>

3. OPERATION

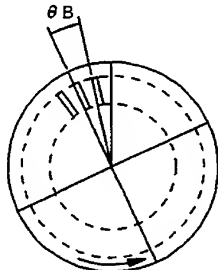
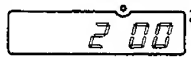
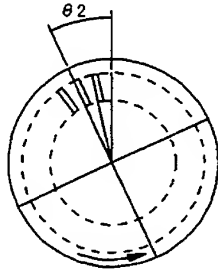

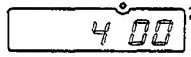
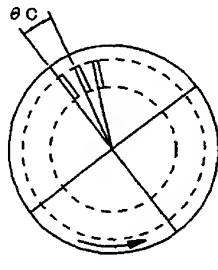


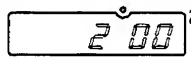
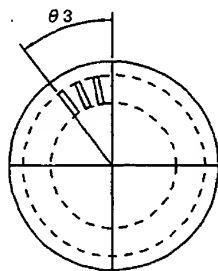

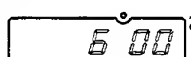
(2) Measuring in ABS/INC mode

Each of the angles of $\theta 1, \theta 2, \theta 3, \theta A, \theta B$, and θC is to be measured.



Procedure	Operation	Screen	Counter operation/Display
Step 1	Prepare for the measurement by referring to the procedure of 3.4. Align the vertex of the angle to be measured with the intersection of the cross-hair lines, then rotate the protractor screen to align one edge of the angle with a cross-hair lines. Set the angle counter to ABS mode and establish a datum on the edge by setting the counter to zero.		<p>Counter</p> <p> </p> <p>Display</p> <p>● ABS </p> <p>○ INC</p>
Step 2	Rotate the protractor screen to measure angle θA .		<p>Display</p> <p>● ABS </p> <p>○ INC</p>
Step 3	Switch to INC mode and set the counter to zero.		<p>Counter</p> <p> </p> <p>Display</p> <p>○ ABS </p> <p>● INC</p>

3. OPERATION

Procedure	Operation	Screen/Profile Projector	Counter operation/Display
Step 4	Rotate the protractor screen to measure the angle θB .		Display <input type="radio"/> ABS  <input checked="" type="radio"/> INC
Step 5	Switch to ABS mode and measure the angle θB .		Counter  Display <input checked="" type="radio"/> ABS  <input type="radio"/> INC
Step 6	Switch to INC mode and set the counter to ZERO. Measure the angle θC .		Counter   Display <input type="radio"/> ABS  <input checked="" type="radio"/> INC
Step 7	Switch to ABS mode and measure the angle $\theta 3$.		Counter  Display <input checked="" type="radio"/> ABS  <input type="radio"/> INC

3. OPERATION

3.8

Troubleshooting

When the profile projector does not work correctly, check the operations by referring to the following points.

Symptom	Possible cause/Check point	Inspection/Remedy
The main switch (power switch) is On, but the pilot lamp is not lit and the fan motor does not work.	① Is the voltage selector set to the voltage?	Set the voltage selector correctly. (Refer to 2.3.4)
	② Is the power cord properly connected?	Connect the cord properly. (Refer to 2.3.5)
	③ Is the fuse OK?	Replace the fuse. (Refer to 4.3.1)
	④ Is the input voltage normal?	Replace the power cord.
	⑤ Does the main switch (power switch) operate normally?	Connecting cable is broken or there is a poor connection (Contact Mitutoyo).
	⑥ Is the input voltage to the main switch (power switch) or fan motor normal?	
	⑦ Is the primary input voltage of the transformer normal?	
The illuminator lamp does not light when the main and illuminator switches are ON.	① Is the fan motor working normally?	Connecting cable is broken or there is a poor connection (Contact Mitutoyo).
	② Is the lamp filament OK?	Replace the lamp. (Refer to 4.3.2)
	③ Does the illuminator switch operate normally?	Contact Mitutoyo if the system does not work correctly even after the checks and remedies described previously are taken.
	④ Is the secondary output voltage of the transformer normal [24, 21, 4V (contour), 24V (surface)]?	
The angle counter is not displayed when the main switch (power switch) is turned ON.	① Does the pilot lamp in the power switch light?	Contact Mitutoyo if the system does not work correctly even after the checks and remedies described in the previous page are taken.
	② Turn the power switch once to OFF and wait for more than 5 seconds. Then turn it again to ON.	If the lamp does not light after two or three tries, contact Mitutoyo.

3. OPERATION

Symptom	Possible cause/Check point	Inspection/Remedy
The angle counter does not count at all.	Turn the power switch once to OFF and wait for more than 5 seconds. Then turn it to again ON and perform angle measurement.	If the counter does not count after tow or three times of trial, contact Mitutoyo.
The angle counter miscounts.	① Is the GND wire grounded correctly?	Ground the GND wire firmly. (Refer to 2.3.4)
	② Is there any strong noise source, such as a large power source or large-current relay, in the vicinity?	Take countermeasures such as moving this profile projector into other place, etc. By referring to 2.3.4 .
	③ Turn the power switch once to OFF and wait for more than 5 seconds. Then turn it ON again and perform the measurement.	If the counter still miscounts after tow or three times of trial, contact Mitutoyo.
The angle counter display is not stable.	Is the system subjected to any vibration?	Take countermeasures such as moving this profile projector to another place, referring to 2.2.2 .
The external counter has problems.	Consult the operation manual of each counter used.	
X, Y-axis counter does not count at all.	Turn the power switch once to OFF and wait for more than 5 seconds. Then turn it to again ON and perform angle measurement.	If the counter does not count after tow or three times of trial, contact Mitutoyo.
X, Y-axis counter miscounts.	① Is the GND wire grounded correctly?	Ground the GND wire firmly. (Refer to 2.3.4)
	② Is there any strong noise source, such as a large power source or large-current relay, in the vicinity?	Take countermeasures such as moving this profile projector into other place, etc. By referring to 2.3.4 .
	③ Turn the power switch once to OFF and wait for more than 5 seconds. Then turn it ON again and perform the measurement.	If the counter still miscounts after tow or three times of trial, contact Mitutoyo.
X, Y-axis counter display is not stable.	Is the system subjected to any vibration?	Take countermeasures such as moving this profile projector to another place, referring to 2.2.2 .

3. OPERATION

Symptom	Possible cause/Check point	Inspection/Remedy
Focusing is not performed smoothly.	Is the operation of the focusing knob smooth?	If there is play or abnormal noise present, contact Mitutoyo. Do not disassemble the unit or force the focusing knob.
Error is observed in glass scale or overlay chat measurement.	This may be a magnification error. Check the magnification accuracy by referring to 2.4.2 (1).	Contact Mitutoyo if normal operation is not achieved after the checks and remedies were carried out according to the instruction as written in the left hand side column.
Abnormal microstage operation, and measurement errors occur.	Check the microstage operation by referring to 2.3.1 and 2.4.2.	
Abnormal protractor screen operation.	Are the operations of screen clamp and screen rotation knob smooth?	If the screen rotation, fine adjustment, or clamp does not work normally, contact Mitutoyo. Do not force them.
Positioning of the surface illuminator unit is not achieved well.	Adjust it by referring to 3.3.2.	If the surface illuminator unit positioning does not go well, contact Mitutoyo. Do not force them.
Partial obscured image.	① Is the projection lens properly mounted?	Mount the projection lens correctly. (Refer to 2.3.3)
	② Is focusing correct?	Perform focusing correctly. (Refer to 3.4)
	③ Are there any stains on or damage to the projection lens?	Clean the projection lens. (Refer to 4.1.1)
	④ Is there any stains or damage to the surface reflecting mirror?	Clean the reflecting mirror. (Refer to 4.1.3)
	⑤ Is there any stains on the projection screen?	Clean the projection screen. (Refer to 4.1.4)
	Contact Mitutoyo if normal operation is not achieved even after the checks and remedies as described above are carried out.	

3. OPERATION

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4. MAINTENANCE

4.1 Maintenance of Optical Components

4.1.1 Projection lens and condenser lens

Compared with ordinary hard glass, the optical glass of the projection lens used for the projection lens or condenser lens is soft and subject to scratches. In order to remove dust do not use a cloth to wipe the lens, but use a blower brush instead. To remove oil or fingerprints, dampen a clean gauze with high-grade alcohol and wipe gently using a circular motion.

For lens storage, replace the lens cap and store it in its case.

Replace the lens cap when the projector is not in use, although the lens does not have to be removed from the projector.

4.1.2 Half-reflecting mirror for surface illuminator (Option)

The half mirror for 5X and 10X is coated with a plastic film which tends to collect dust. Since the mirror surface is subject to scratches, take sufficient care when handling it. Use a blower brush to remove any dust from the mirror.

4.1.3 Mirror (surface reflection mirror)

The mirrors inside the machine are delicate and should never be touched by your hands or anything else. Take care not to allow dust or oil mist inside the machine. Should the mirror have to be cleaned, dust must be blown away with a blower, instead of being wiped off.

4.1.4 Screen glass

Use a soft cloth soaked in a neutral detergent solution for wiping stains from the screen glass. After wiping, remove the detergent with a soft cloth soaked in water.

Wring both cloths well before wiping to prevent water from entering the projector through the edge of the glass.



CAUTION

Wring both cloths well before wiping to prevent liquid from entering the projector. Do not use a solvent, such as a thinner or ether, for cleaning; they may remove the cross-hairs and graduations on the screen.

4.2 Maintenance of Mechanical Components

The maintenance method for the mechanical components of the profile projector is explained in the following.

4.2.1 Projector main unit

Periodically apply a thin coat of grease on the feed screws and gears of the microstage vertical travel using a brush.

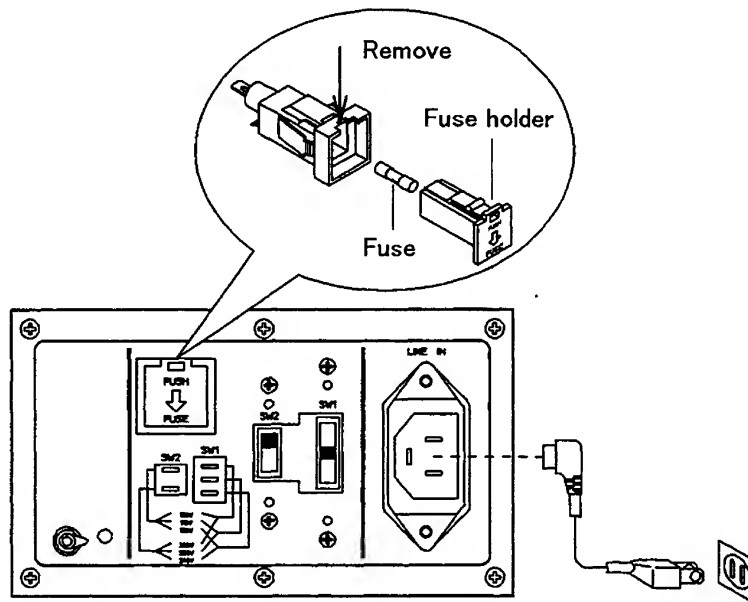
4.2.2 Microstage

Remove the microstage from the projector and apply a small amount of spindle oil to the V-groove guide rail.

4. MAINTENANCE

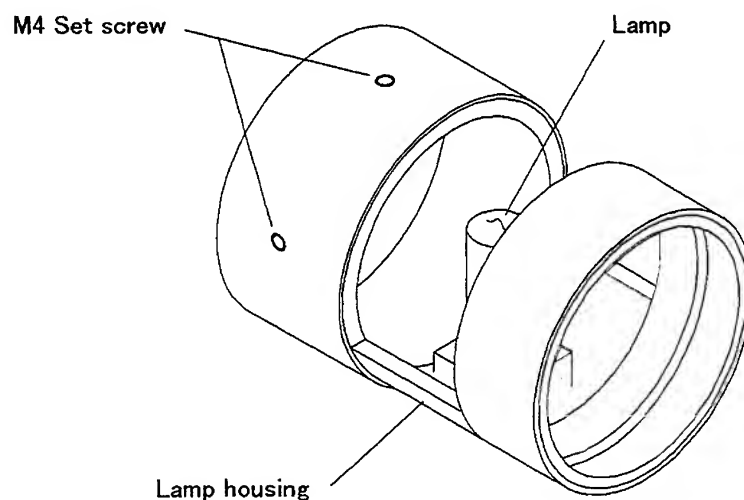
4.3 Replacing Disposable Parts

4.3.1 Fuse



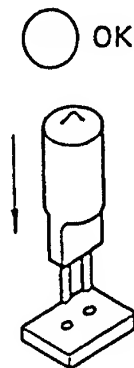
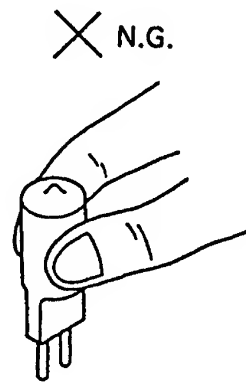
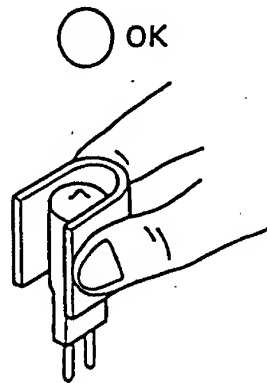
- Step 1: Turn the main switch to OFF.
- Step 2: Pull the power plug from the power outlet.
- Step 3: Inserting a watch maker's screw in the slot on the upper.
- Step 4: Insert the fuse holder in the case unit it clicks.


4.3.2 Bulbs for contour and surface illuminators



4. MAINTENANCE

- Step 1: Turn the main switch to off.
Step 2: Open the door of the contour illuminator unit.
Step 3: Loosen the clamp screw and remove the lamp housing.
Step 4: To remove the bulb, hold it gently using a soft cloth or paper and pull it straight out from the lamp housing.



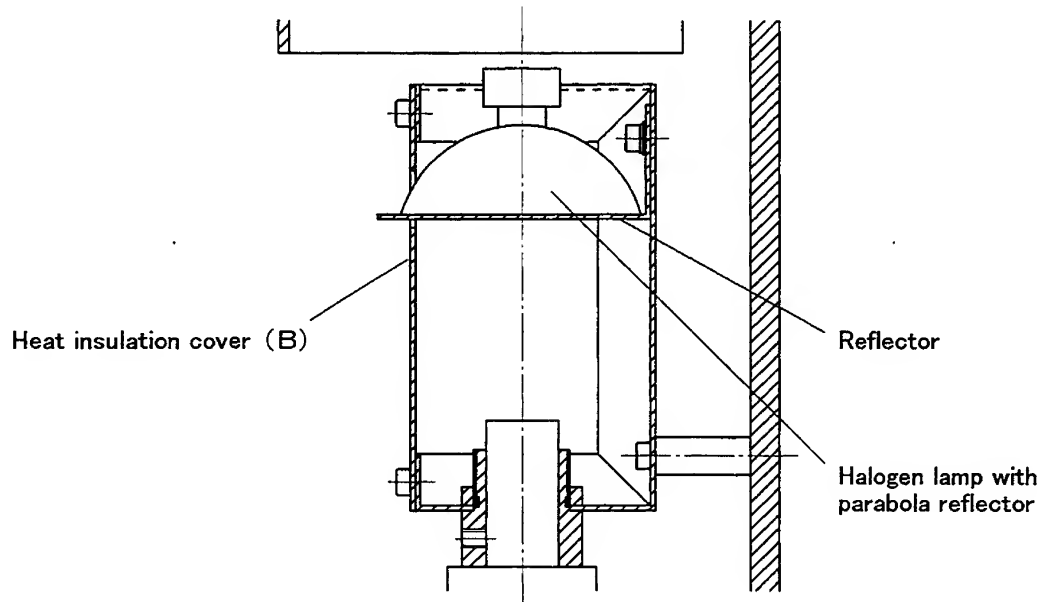
- Note 4.2
- 
1. To prevent personal injury, do not touch a hot bulb during use or immediately after turning it off.
 2. To prevent the bulb from being stained with oil or finger-prints, do not touch the bulb with your hand.
 3. Do not apply force to the bulb pin in the horizontal direction, or the bulb could be destroyed.

- Step 5: To mount the bulb, insert it straight into the socket as far as it can go so that the bulb filament image is centered in the convex mirror.
Step 6: Insert the lamp housing that has the new lamp into the contour illuminator in reverse order of the procedures step 1 to step 3.

4. MAINTENANCE

4.3.3

Twin fiver—optic illuminator (oblique reflected) lamp



- Step 1: Turn the main switch to off.
- Step 2: Remove the protection cover for contour and surface light sources.
- Step 3: Remove the heat insulation cover (B)
- Step 4: Pull out the parabola reflector together with the halogen lamp from the retainer.
- Step 5: Pull the lamp straight up from the parabola reflector.
Don't touch the lamp with bare hand.
- Step 6: Insert a lamp in the parabola reflector by inserting it straight to its extreme end.
- Step 7: Replete the parabola reflector in place reversing steps 3 through 1 in this order

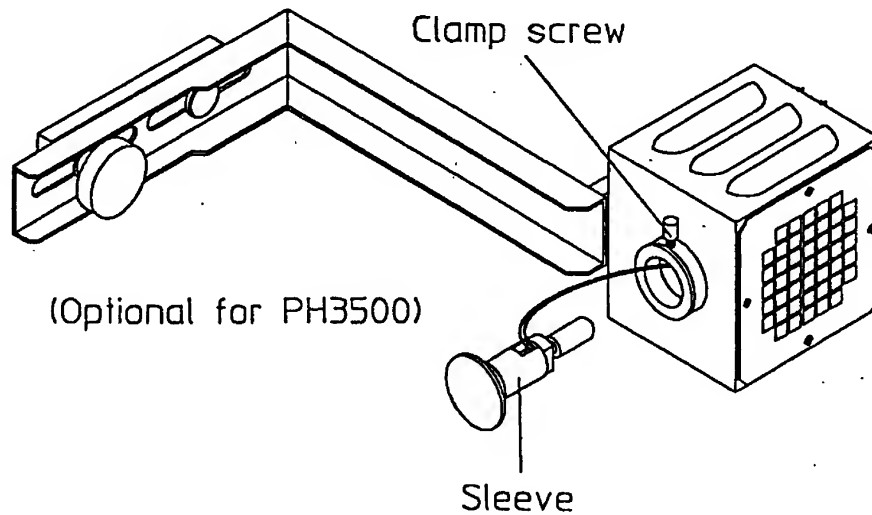
4. MAINTENANCE

4.3.4

Surface illuminator lamp (option)

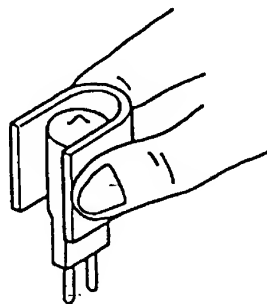
Step 1: Turn the main switch to off.

Step 2: Loosen the clamp screw and pull out the sleeve.

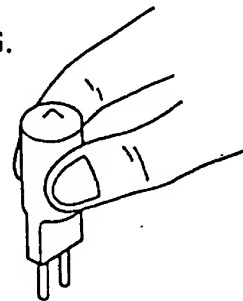


Step 3: To remove the bulb, hold it gently using a soft cloth or paper and pull it straight out from the lamp housing.

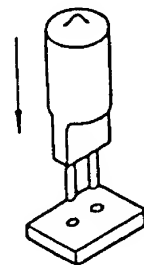
○ OK



× N.G.



○ OK



× N.G.



Step 4: To mount the bulb, inset it straight into the socket as far as it can go.

Step 5: Adjust the filament position according to 2.5.2.

Step 6: Insert the lamp housing that has attached a new lamp into the contour illuminator in reverse order of the procedures step 1 to step 3.

4. MAINTENANCE

4.4

Periodic Inspection

In order to obtain a long service life of the PH—3500 Profile Projectors, periodically perform inspection, cleaning, and necessary lubrication.

For the items and contents of the periodic inspections, refer to 2.4 Initial Check.

4.5

List of Parts for Maintenance

Part No.	Description		Quantity
515530	Halogen lamp	24V-150W (50H)	2
12AAA637	Parabola halogen lamp	24V-200W	1
515530	Halogen lamp(option)	24V-150W (50H)	1
512467	Tube fuse	100V,110V,120V MF-60 NR 125V 10A AC05	1
510188		220V,240V MF-60 NR 125V 5A AC05	
358191		220V,240V (CSA) 6A	
284211		220V,240V (CSA) 5A	

4. MAINTENANCE

MEMO

5. SPECIFICATIONS

5.1

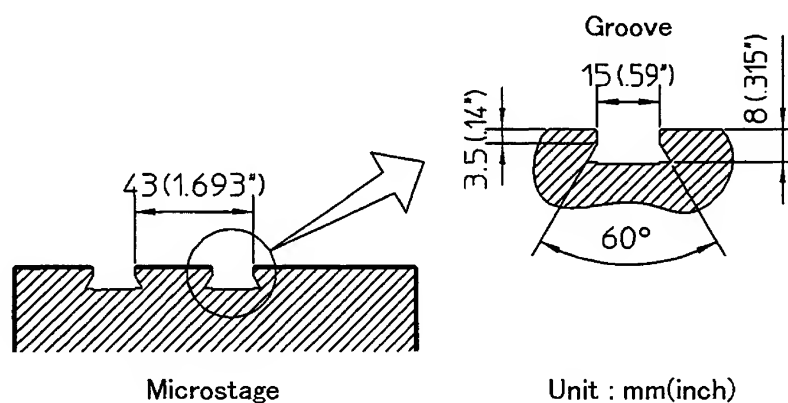
Specifications of the Main Unit

Item	Description
Protractor screen	Effective measurement diameter : 353mm (13.9")
	Angle display : Digital
	Resolution : 1' or 0.01° selectable
	Measuring range : $\pm 370^\circ$
	Angle counter : Zero setting, ABS/INC mode selection
	Fine ground glass
	Cart hold : Detachable 4 chart clips
Projection lens	10X (standard accessory)
	5X, 20X, 50X (option)
Microstage (X-axis)	Size : 450X146mm (17.7" \times 5.7")
	Count unit : Linear Scale AT112-270 with 1 μ m resolution (incorporated in the microstage)
	Number of grooves and interval (refer to the diagram of cross-section) : 2 grooves P=43mm (1.69")
	Measuring range : 254mm (10.0")
	Maximum loading capacity : 45kg (99 lbs.)
	Swivel angle : $\pm 10^\circ$
	Angle resolution : 30°
Y-axis	X-axis floating is possible
	Measuring range : 152mm (6.0")
X,Y counter	Count unit : Linear Scale AT112-170 with 1 μ m resolution (incorporated in the main unit)
	Function : Zero setting, Direction mode selection
	Display range (mm/E) ± 8388.607 (inch/mm) ± 330.2061
	Resolution : 0.001mm (0.0001")
Main unit dimension	Number of axis : 2 axis (X,Y-axis)
	W \times D \times H : 460 \times 1138 \times 1155mm
Magnification accuracy	Screen center height : 935mm (36.8")
	Contour illumination : $\pm 0.1\%$ or less
Focusing range	Surface illumination : $\pm 0.15\%$ or less
	50.8mm (2.0")

5. SPECIFICATIONS

Item	Description
Contour illumination system	Light source : 24V, 150W halogen lamp
	Telecentric illumination
	2 stage brightness selector
	Built-in heat absorbing filter and cooling fan
	Color filter (options) is available
Oblique reflected illumination system	Light source : 24V, 150W halogen lamp
	Twin fiber-optic illuminator
	Condensing adjust ability of luminous flux
Power source (external selector)	AC100, 110, 120, 220,240V (selector)
	Single-phase : 50/60Hz
	Power cord : 2mm (78.7")
Operating conditions	Temperature (in operation) : 0 to 40°C
	Accuracy warranty : $20 \pm 1^\circ\text{C}$
	Humidity (in operation) : 20 ~ 80%
	Dust : General precision measuring room conditions

- Cross-sectional view of the microstage



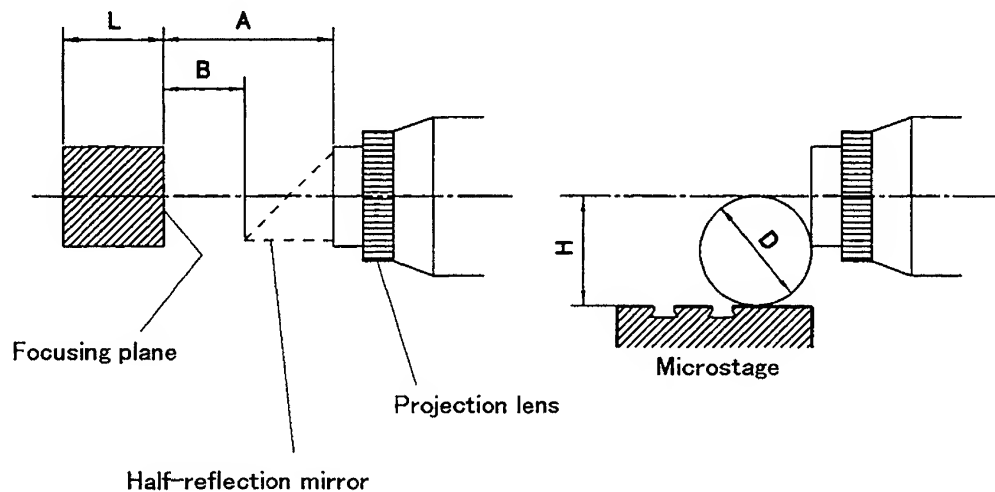
5. SPECIFICATIONS

5.2

Projection Specifications

The following projection lenses are available for this profile projector, either as a standard or as an option.

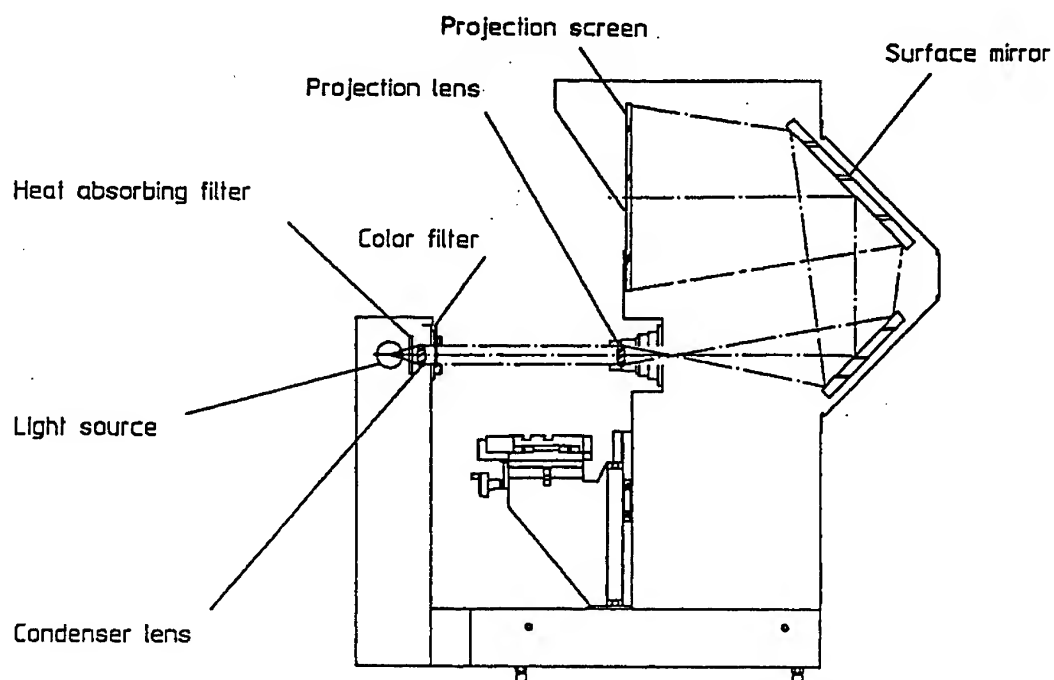
		Unit : mm(inch)				
Magnification		5 ×	10 ×	20 ×	50 ×	
Mounting method		Screw mount				
Magnification Accuracy	Contour illumination	±0.1%				
	Twin fiber					
	Surface illumination	±0.15%				
Projection capability	Field of view	71.2 (2.803")	35.6 (1.402")	17.8 (.701")	7.12 (.280")	
	Maximum working distance	A	160 (6.299")	93 (3.661")	40 (1.574")	14.6 (.575")
		B	64 (2.519")	41 (1.614")	40 (1.574")	14.6 (.575")
	Maximum workpiece height	L	175 (6.890")	235 (9.252")	235 (9.252")	80 (3.150")
	Maximum projecting diameter	D	152.4 (6")	152.4 (6")	116 (4.567")	30.4 (1.197")
	Maximum distance between the optical axis and microstage top face	H	152.4 (6")			



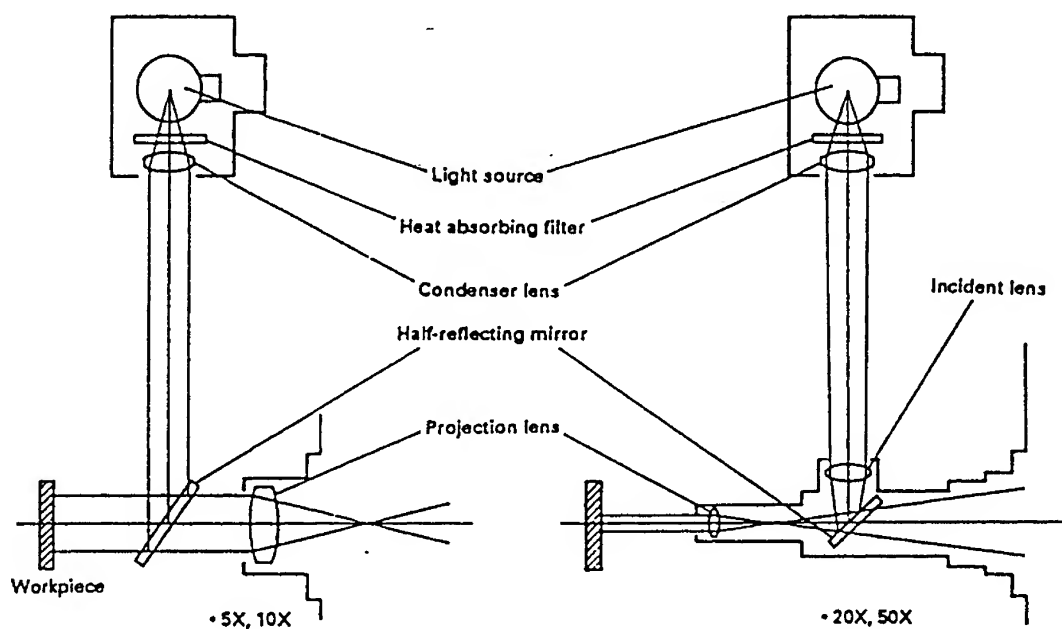
5. SPECIFICATIONS

5.3 Optical Path

5.3.1 Optical system of the contour illuminator



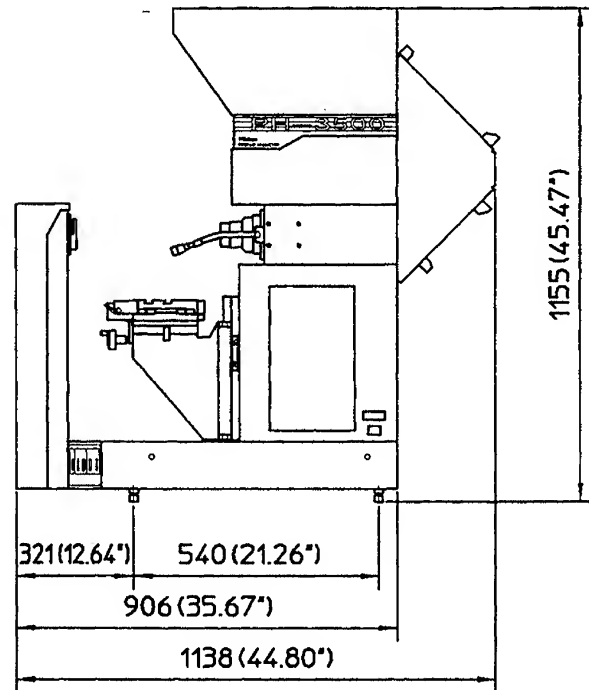
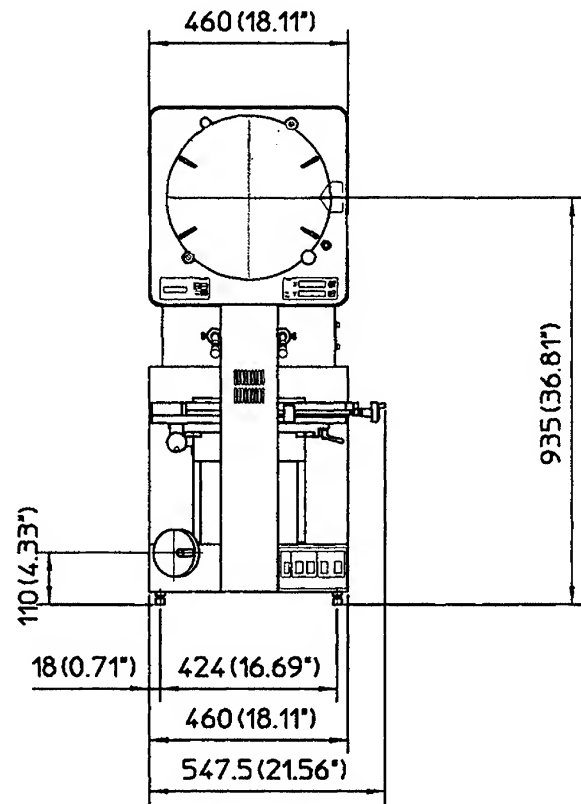
5.3.2 Optical system of the surface illuminator (option)



5. SPECIFICATIONS

5.4

Dimensions



Unit : mm(inch)

5. SPECIFICATIONS

5.5

Accessories

5.5.1

Standard accessories

Code No.	Name		Quantity
172-184	Projection lens : 10 × set		1
515530	Halogen lamp : 24V 150W		2
☆ 12BAA637	Halogen lamp : 24V 150W (Twin fiber)		1
512926	Cap		4
◇ 930965	Power cord	(JAPAN) 100V	1
◇ 930966		(MTI) 120V	
◇ 930967		(DS) 220V	
◇ 930968		(AUSTRALIA) 220 ~ 240V	
◇ 998614		(BS Plug) (CE) 220 ~ 240V	
———	Grounding wire		1
※ ———	Tube fuse : MF-60NR 125V 10A AC05		1
※ ———	Tube fuse : MF-60 250V 5A AC05		
———	Tube fuse : BS SEMKO S506 5A (CE)		
383228	Vinyl cover		1
99MB007J-5	Optional manual		1
99MB007A-5	Optional manual		
———	Warranty card		1

☆ Make is new

◇ Varies depending on the country.


※ 10A fuse : for 100, 110, 120 VAC

※ 5A fuse : for 220, 240 VAC

5. SPECIFICATIONS

5.5.2

Optional accessories

Code No.	Name		
172-145	Projection lens	5 × set	
172-173		20 ×	
172-165		50 × set	
172-294	Half mirror	5 ×	
172-295		10 ×	
172-116 (117)	Standard scale	50mm (2")	
172-118 (119)	Reading scale	200mm (8")	
172-161 (162)	Reading scale	300mm (12")	
932105	Miler screen	(12 sets)	
270032	Attachment board for Optoeye Sensor		
172-286	Color filter		
172-143	Riser		
172-142	Center support		
172-144	Rotary vise		
264-137	Micropak 7		
264-135	Micropak 5		
965058	OPT-A2 interface		
332-115-1	Optoeye A2 counter		
937179T	Fit-switch		
172-132	Vertical workpiece holder		
172-234	V-block		
172-133	Surface illuminator		
990271	Counter support stand		
512066		Overlay chart	
512067			
512068			
512069			
512070			
512071			
512072			
512073			
512074			
512075			
512076			
512077			
☆ 172-001	Tip-saw support stand (ϕ 25.4mm, 1")		
☆ 172-002	Cutter support stand (ϕ 25.4mm, 1")		
172-276	Processor stand		
936937	cable 1m (2 sets)		

☆ Mark is new

5. SPECIFICATIONS

MEMO

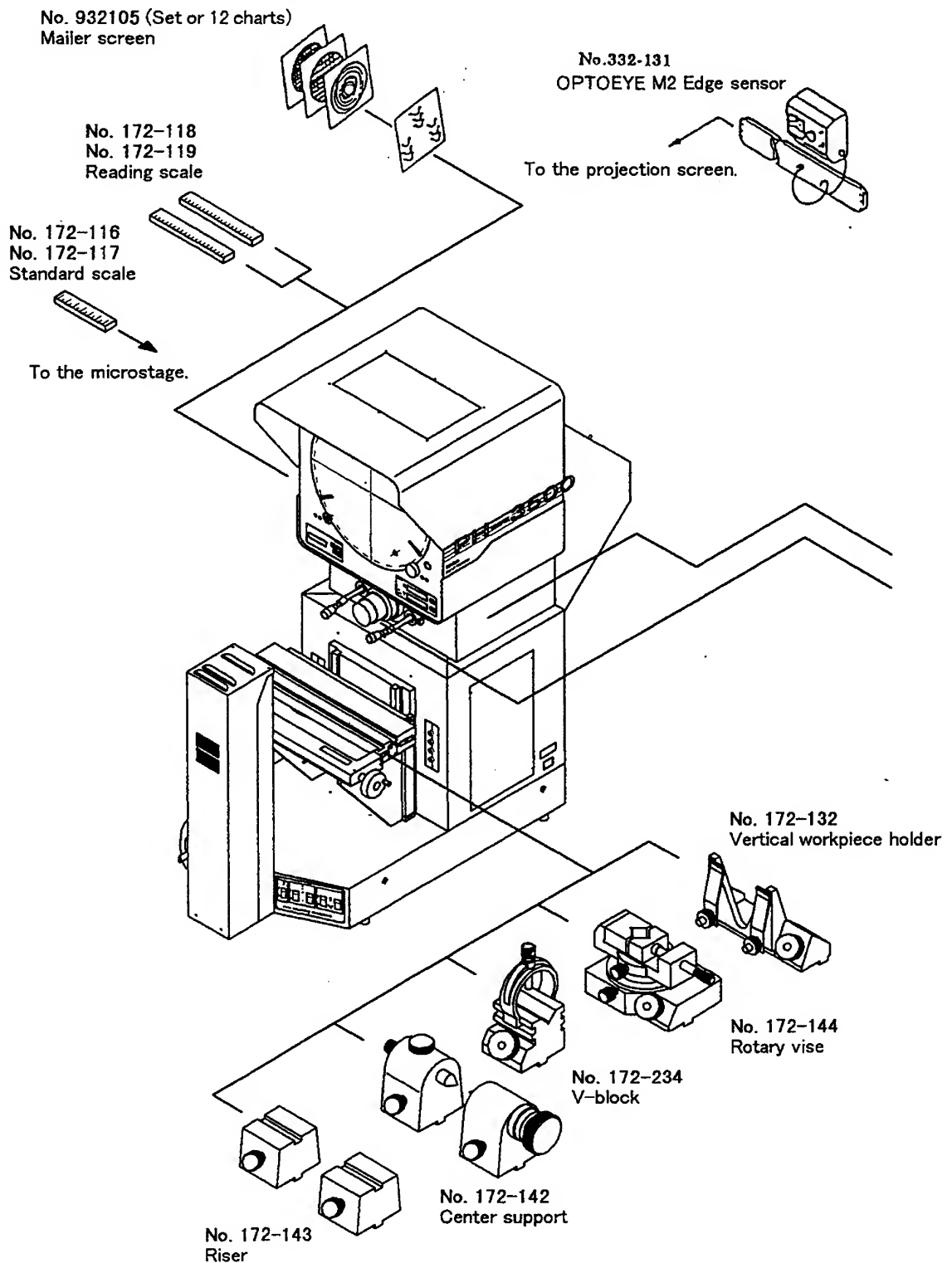
5. SPECIFICATIONS

5.6

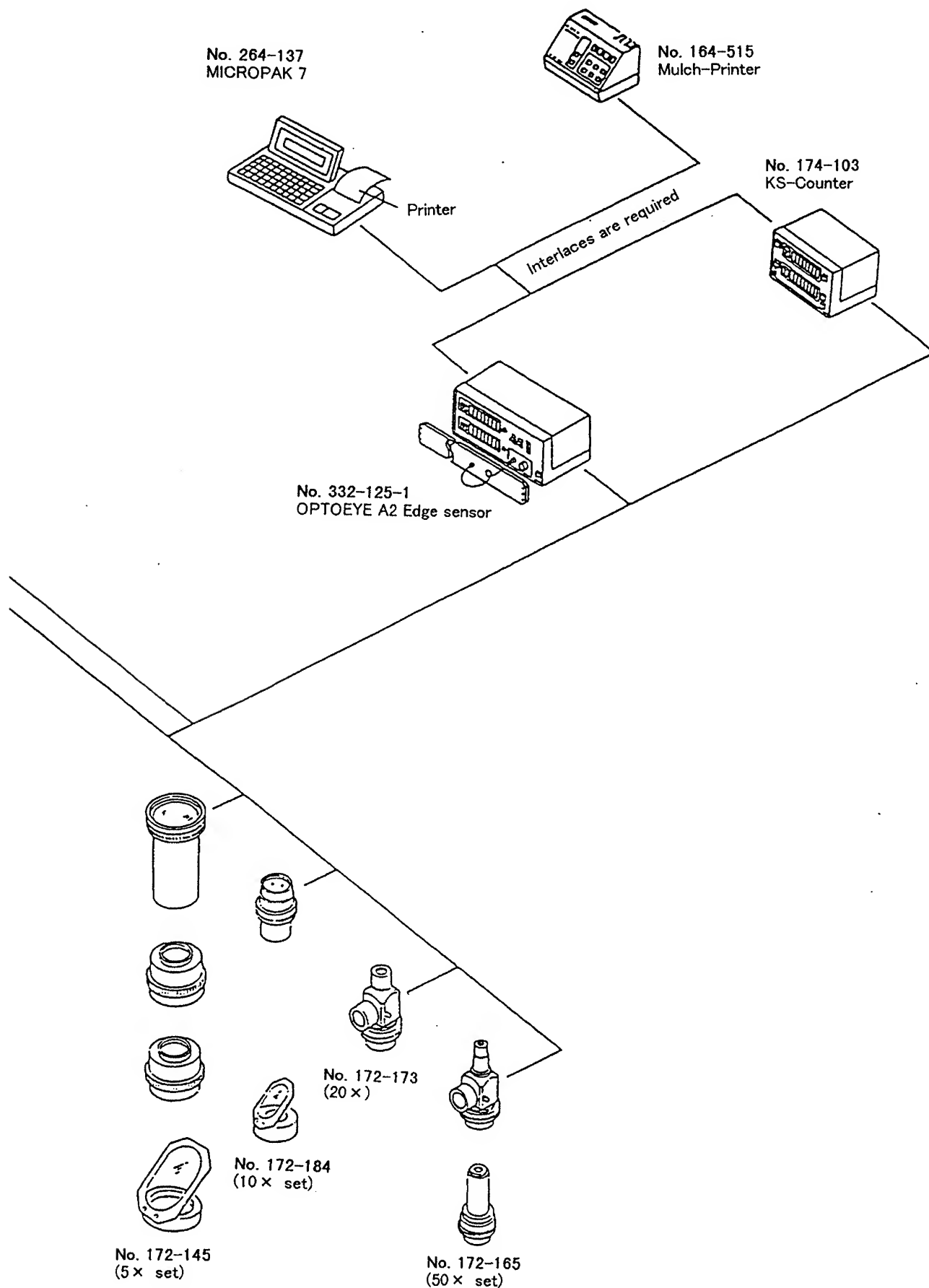
System Configuration

5.6.1

System block diagram



5. SPECIFICATIONS



APPENDIX

1.

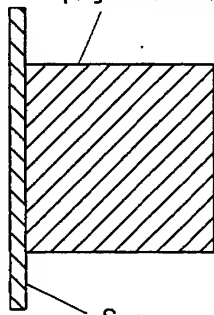
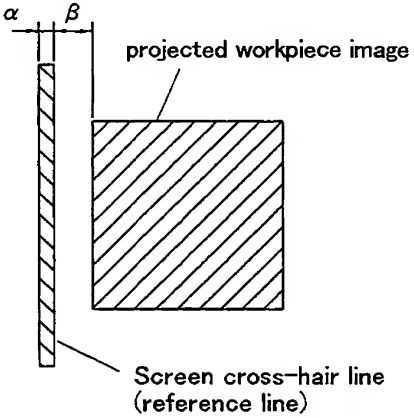
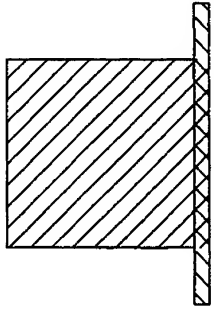
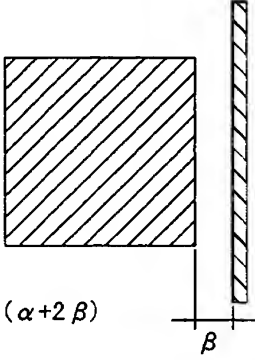
ALIGNMENT ERROR

“Alignment error” is the error in alignment between the projected image of the workpiece and the cross-hair lines (reference lines) on the screen.

The alignment error is affected by the workpiece edge conditions and by the method of alignment used.

1.1

Alignment Methods

Procedure	Method A	Method B
Step 1	 <p>projected workpiece image</p> <p>Screen cross-hair line (reference line)</p>	 <p>projected workpiece image</p> <p>Screen cross-hair line (reference line)</p> <p>α β</p>
Step 2	 <p>Align the edge of the projected image within the width of the staggered cross-hair line in the screen.</p>	 <p>$D = d - (\alpha + 2\beta)$</p> <p>$D$: Dimension to be measured d : Width screen cross-hair line α : Measured value β : Clearance</p>

- Although alignment error occur regardless of the method (A or B) used, method B has smaller degree of error than method A, especially for low magnification measurement.

1.2

Errors due the Workpiece Edge Conditions

The edge of the projected image may not be clearly seen may appear convex or concave, depending on the surface conditions of the edge. This phenomenon's more significant with increased magnification, thereby affecting the alignment error.

Generally, the higher the magnification, the less the alignment error ,as the image is clearer and lines are sharper. However, this does not always imply a simple proportional relationship between magnification and alignment error because of the fact shown above. Two examples are be considered as follows.

- Alignment error of a knife edge
- Alignment error of cylindrical plug gauge
- The alignment error of a knife edge with good end conditions varies little despite increased magnification, because the knife edge will be very clearly seen at any magnification. On the other hand, the alignment error of a plug gauge edge decreases greatly with increased magnification. Therefore for blunt edges the alignment error decreases with magnification, while for clearly defined edges, increased magnification does not necessarily decrease it.
- Factors other than the above cause alignment errors. Giving due consideration to the alignment method and the workpiece edge conditions, select an appropriate measuring method to minimize alignment errors.

APPENDIX

MEMO

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